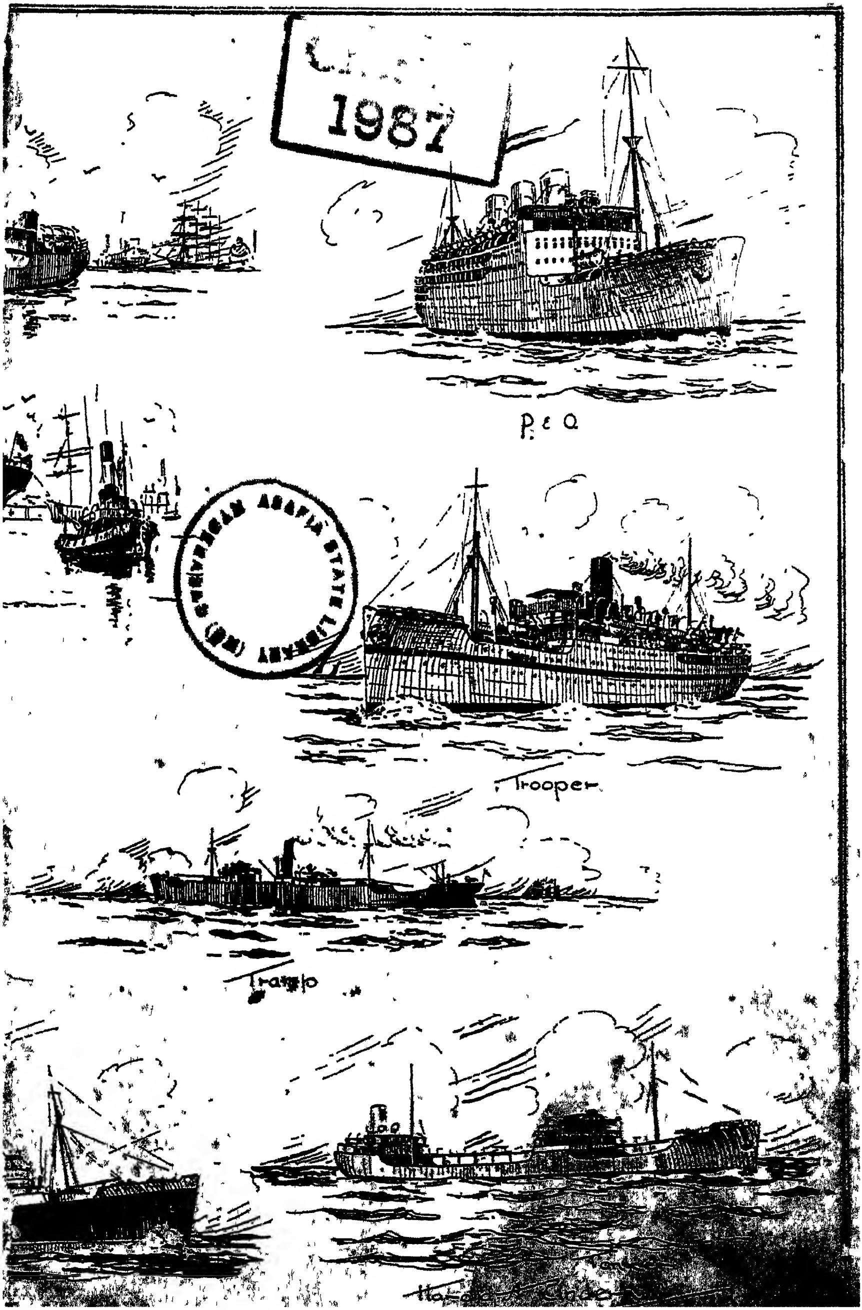
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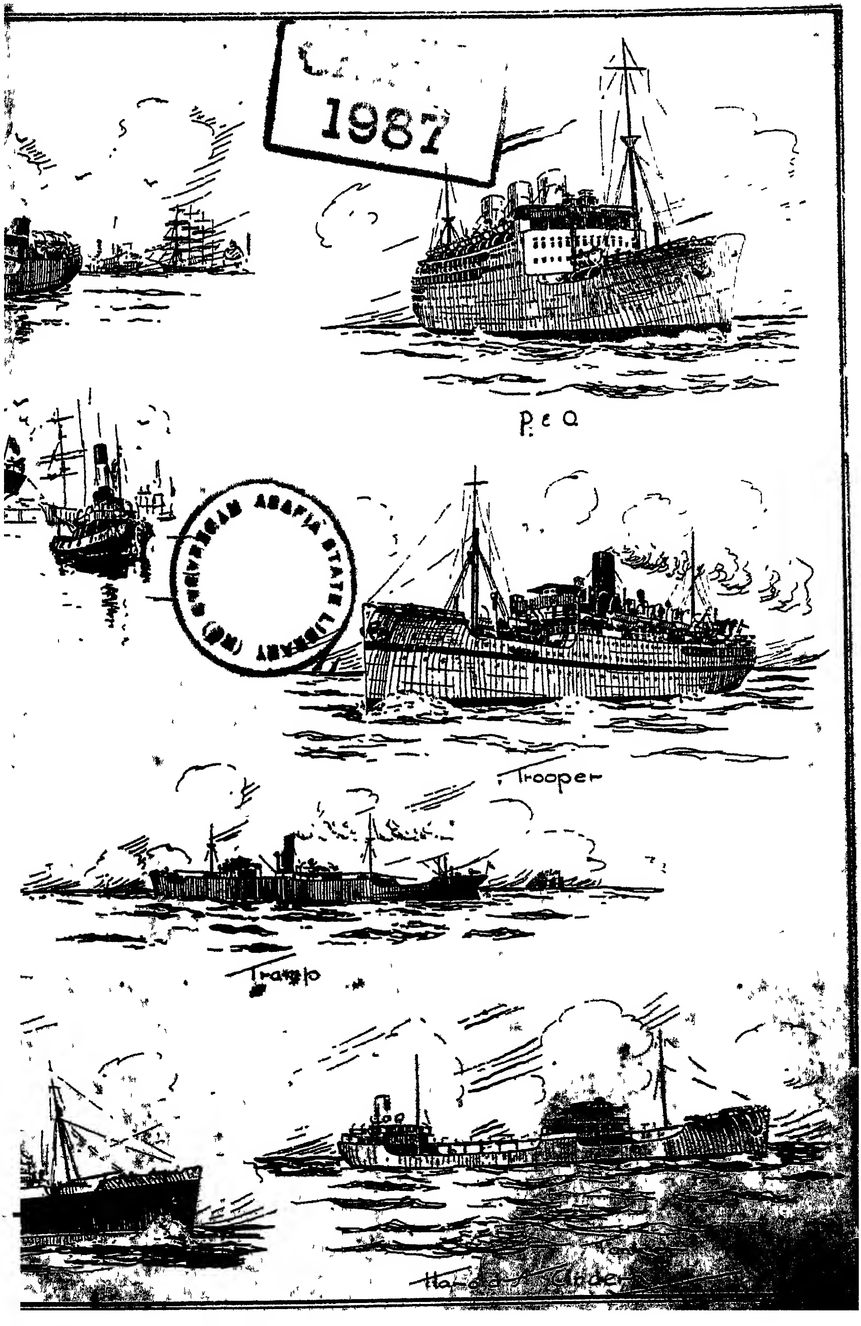
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NICHOLLS'S
SEAMANSHIP AND NAUTICAL KNOWLEDGE

Wheelhouse Equipment.

NICHOLLS'S

Seamanship and Nautical Knowledge

FOR

Second Mates', Mates' and Masters'

Examinations

BY

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ENTERED AT STATIONERS' HALL

GLASGOW

BROWN, SON & FERGUSON, LTD., NAUTICAL PUBLISHERS

52 TO 58 DARNLEY STREET

18th Edition	- -	1938
Reprinted	- - -	1939
,,	- - -	1940
,,	- *April,*	1941
,,	*November,*	1941
,,	- *June,*	1942
,,	- *June,*	1943
,,	- *March,*	1944
,,	- *March,*	1945
,,	- *January,*	1946
,,	- *January,*	1947
,,	- *March,*	1948

Made and Printed in Great Britain by
BROWN, SON & FERGUSON, LTD., GLASGOW, S.1.

PREFACE.

It is not easy to define the scope of modern academic seamanship as it includes within its limits more than a passing knowledge of mechanics and physics; the Merchant Shipping Act and Statutory Regulations as affecting ships, cargoes and seamen; the structure of the vessel, her stability, equipment, internal organisation and mobility; the conveyance of cargoes and the working of the ship as an economic unit, together with a general knowledge of many nautical things which the seamen may never be called upon to exercise in practice.

The ideal seaman is he who says and does the proper thing in just the proper way and at the proper time, a man who has developed sea sense and nautical sagacity. But ideal conditions and the ideal man seldom, if ever, confront each other in an emergency at sea.

No man can hope to acquire a full and complete knowledge of all nautical subjects either from the personal experiences of a lifetime or from a prolonged reading of textbooks, but the prudent seaman reads every shipping publication that comes his way, takes reasonable precautions and studies the ways of ships and men, visualises possible contingencies and mentally decides what action he would take in the event of sudden emergency.

We do not pretend to have treated any of the subjects exhaustively; the student who wishes to specialise must refer to recognised textbooks written by experts. We have aimed, rather, at a simple introduction of several aspects of seamanship, referring to fundamental principles in cases where such exist, and developing the several themes up to a reasonable examination standard. There is not a clear demarcation in the Board of Trade syllabuses between the amount of knowledge required for the several grades but, obviously, Masters are expected to have a fuller and more intimate knowledge of various things than First Mates, and First Mates than Second Mates, so it behoves the beginner to assimilate as much information as his experience and capacity will admit.

Much of the candidate's knowledge is pure memory work—Statutory Regulations, for example—devised, mainly, to bring about uniformity

of practice, and a knowledge of these can only be acquired by frequent reference and repetition, hence the reason why some of the information is conveyed in the form of Questions and Answers.

We have drawn largely on the experience of others as their knowledge has enabled us to collate the varied information which forms the basis of the Board of Trade Oral Examinations for Certificates of Competency as Second Mates, Mates and Masters.

I am indebted to numerous friends and colleagues for advice and guidance in the preparation of this work and gratefully acknowledge their assistance, also the kindness of many firms in granting permission to reproduce illustrations from their publications, and particularly to Mr. William M. Gray, B.Sc., M.I.N.A., for criticism and many of the drawings which illustrate the chapter on Ship Construction, also to—

Messrs. Allan Whyte & Co., Glasgow Wire Rope Manufacturers.

Brassey's Naval Annual.

The British Mannesmann Tube Co., London. Derricks.

Messrs. Brown, Lennox & Co., London. Anchors, Cables and Buoys.

Messrs. Bruntons (Musselburgh), Ltd., Musselburgh Wire Ropes.

Messrs. The Bergius Co., Ltd., Glasgow. Kelvin Motor Engines.

Messrs. Chadburn's (Ship) Telegraph Co., Ltd., Liverpool. Ship Telegraphs.

Messrs. Davey & Co., London. Blocks and Tackles.

The Electric Submerged Log Co., London.

Messrs. Emerson, Walker Ltd., Gateshead-on-Tyne. Steam Capstans and Windlasses.

Messrs. Haslam & Newton, Ltd., Derby. Refrigerating Plant.

Messrs. Henry Hughes & Son, Ltd., London. Echo Sounding Machines.

Messrs. John Hastie & Co., Greenock. Steering Engines.

The Imperial Merchant Service Guild. Forrest's Jury Rudder.

The Radio Communication Co., Ltd., London. Direction Finders.

Messrs. Kelvin, Bottomley & Baird, Ltd., Glasgow. Sounding Machines; Pneumercator Tank and Draught Gauges.

Messrs. New Zealand Shipping Company, London.

Shipbuilding and Shipping Record.

The Shermuly Pistol Rocket Apparatus, Ltd., London. Line-Throwing Gun.

Messrs. Sliding Hatch Beams ("T & B" Patents) Ltd., London.

Messrs. Stewarts & Lloyds, Ltd., Glasgow. Tubular Davits.

Messrs. J. Stone & Co., Ltd., London. Hydraulic Watertight Bulkhead Doors.

The Submarine Boat Corporation, Newark, N.J. Shipyard Illustrations.

Messrs. Taylor, Pallister & Co., Ltd., Dunston-on-Tyne. The "Dunstos" Patent Rudder Brake.

Messrs. Welin & Co., London, and Messrs. Welin-Maclachlan Davits Ltd., Glasgow. Boat Davits and Gear.

The Yachting World.

NOTE.

Where "Board of Trade" is referred to in this book substitute "Ministry of Transport" which is now responsible for legislation formerly administered by the Marine Department, Board of Trade.

CONTENTS.

CONTENTS

SYLLABUSES.

WE give here the Ministry of Transport Examination Syllabuses for all grades and have inserted Roman Numerals against the paragraphs to indicate the chapters in this book where reference is made to the subjects named, with the exception of "Engineering Knowledge," which has not been referred to.

The Syllabuses of the Merchant Navy Training Board which, in effect is similar to that of the Ministry of Shipping for Second Mate Certificates, is also given for each year of apprenticeship, but re-arranged to meet the order of presentation adopted in this text-book, together with the pagings of the various items for convenience of reference to facilitate the work of instructors and of students at sea.

Specimen examination papers are given at the end of the book.

SECOND MATE (FOREIGN-GOING).

35. **General.**—Candidates should demonstrate their understanding of their work by means of sketches and figures drawn with reasonable accuracy but not to scale.

The "Knowledge of Principles" paper is intended to test the candidate's grasp of fundamental technical ideas and processes required in his work at sea. Mathematical proofs of formulae are not required, but a candidate should be able to demonstrate the truth of a formula by means of a figure where possible.

36. *Paper* 1. **Knowledge of Principles.** (3 hours.)

(*a*) The reading of simple graphical diagrams, *e.g.*, stability curves, weather statistics, etc. (XVIII.) Also Chapter III., Volume I., *Nicholls's Guide.*

(*c*) Areas and perimeters of rectangle, triangle, circle, volumes, and surface areas of box-shaped bodies, cylinders and wedges. Practical applications, *e.g.* weight of general cargo of varied shapes; capacities of holds and bunkers; weight of contents of bunkers. (XIV.) Also Chapter IV., Volume I., *Nicholls's Guide.*

(*e*) Trigonometrical ratios—sine, cosine, tangent, cosecant, secant, co-tangent, haversine.

The simple relations between these ratios. The relation between the ratios of angles which together make (*a*) one right angle, (*b*) two right angles, *e.g.*, the sine of an angle = the cosine of its complement, etc Chapter VI., Volume I., *Nicholls's Guide*

40. Paper 5. Cargo Work and Elementary Ship Construction. (3 hours.)

(*a*) The stowage and dunnaging of different varieties of cargoes, including bulk cargoes. Elementary ideas on the making and use of cargo plans

The preparation for stowage, breaking out and discharge of cargo

Rigging a ship for loading and discharging cargo, and the use of derricks and winches. Strength of cargo gear.

The calculation of capacities of bunkers, holds, tanks and boats.

Calculation of capacities taken up by part cargoes and of space remaining. Conversion of weight measurement of cargo into space measurement and *vice versa*. (III , IV , XIV , XVI)

(*b*) The names of the principal parts of a ship

General ideas on ship construction and hull maintenance.

The candidate will be expected to show his practical acquaintance with certain portions of his own ship, *e g*. longitudinal and transverse framing Bulkheads. Hatches. Rudders and steering gear. Shell plating. Stern frame Propellers and propeller shafts, stern tube, propeller brackets.

The stiffening and strengthening to resist panting, pounding and propeller vibrations

Double bottom tanks, bilges, bilge pumps, sounding pipes Ventilation systems of holds and tanks (XVII)

(*c*) Displacement Deadweight.

Use of tons per inch immersion scale. Calculation of weight of cargo, etc., from draughts.

Effect of varying density of water.

Buoyancy. Centre of gravity and centre of buoyancy. The laws of floating bodies.

Effect of filling and emptying ballast tanks on centre of gravity of ship as a whole. (XVIII)

41. Paper 6. English. (1½ hours.)

The paper will be designed to test the candidate's ability to write clear and grammatical English with due attention to spelling and penmanship. It will be in no sense a test of technical knowledge.

42. Oral and Practical Portions.

1.—(*a*) Rigging of ships. Strength of ropes, wire and hemp. Rigging purchases of various kinds and knowledge of power gained by purchases Knotting and splicing hemp and steel ropes with strict reference to current practice. Seizings, racking, chain stoppers, etc.

(*b*) Sending topmasts up and down.

(*c*) Bending, setting and taking in fore and aft sails. Management of boats under oars and sail and in heavy weather. Beaching or landing Coming alongside.

(*d*) Helm orders. Conning the ship. (I. to VI)

2.—(*a*) Marking and use of ordinary lead line.

(*b*) Use and upkeep of mechanical logs and sounding machines.

(*c*) Use and upkeep of engine room and other telegraphs.

(*d*) Rocket and line throwing apparatus. (VIII., XI.)

3.—(*a*) Anchors and cables. Use, upkeep and survey.

(*b*) Knowledge of use and maintenance of deck appliances and steering gear.

(*c*) Fire extinguishing apparatus—steam, chemical and other appliances. (VII., VIII., XI.)

4.—(*a*) Preparations and precautions for getting under way. Duties prior to proceeding to sea, making harbour or coming alongside, especially at after end of ship.

(*b*) Keeping an anchor watch. Dragging anchor.

(*c*) Duties of officer of the watch. Use of compass to ascertain risk of collision. (VIII., XIII.)

5.—(*a*) A full knowledge of the content and application of the Regulations for Preventing Collision at Sea. (Candidates will not be placed in the position of handling a sailing ship, but will be expected to recognise a sailing ship's lights and to have a knowledge of her possible manoeuvres according to the direction of the wind.)

(*b*) Distress and pilot signals, penalties for misuse.

(*c*) British uniform system of buoyage.

(*d*) An intelligent use of "Notices to Mariners." (Candidates will not be required to commit these to memory.) (IX., X., XI.)

6.—*Signals.*

To send and receive signals in:—

(*a*) British Semaphore up to eight words per minute.

(*b*) Morse Code by flash lamp up to six words per minute.

(*c*) International Code of Signals. (XIX.)

7. *Practical.*

(*a*) To read and understand a barometer, thermometer, hydrometer and hygrometer. (The instruments supplied by the Meteorological Office will be taken as standard.)

(*b*) To use an azimuth mirror, pelorus (bearing plate) or other instrument for taking bearings, to place these bearings on a chart, having corrected for given compass error.

(*c*) To use a sextant for taking vertical and horizontal angles; to read a sextant both on and off the arc.

(*d*) To correct a sextant into which has been introduced some or all of perpendicularity, side and index errors.

(*e*) To find the index error of a given sextant.

(*f*) To check chronometers by signal made by buzzer or other method, to compare two chronometers. (VIII.) Also Chapters XII., XIII., Volume I., *Nicholls's Guide.*

8.—The Examiner may ask the candidate questions arising out of the written work, if he deems it necessary on account of weakness shown by the candidate. (This applies particularly to Paper 5.)

FIRST MATE (FOREIGN-GOING).

48. Paper 4 (Written.) **Ship Construction and Stability.** (3 hours.)

(*a*) A general knowledge of the principal structural members of a ship. Midship sections of different types of ships, giving the parts their proper names. Scaling dimensions on a midship section to make intelligible reports.

Ability to set out in a clear manner a report on damage sustained by corrosion or by accident.

Construction and stiffening of watertight bulkheads.

Collision bulkhead.

Stern frame and stem and how secured.

Stresses and strains in ships through effect of seas or loading and ballasting.

A knowledge of those portions of a ship specially strengthened to withstand such stresses, or where excessive damage by corrosion is liable to occur.

Rivets and riveting. Testing a line of rivets. Testing watertight work.

Rudders and steering gear. Inspection and maintenance.

Hatches and hatch gear. Hawsepipes and cable lockers.

(*b*) Buoyancy and reserve buoyancy. The righting couple when a ship

is inclined. Metacentre and metacentric height Transverse and longitudinal metacentres. Stiff and tender ships—how to obtain stiffness. Stability at large angles of inclination and what this depends on

Preparation of data for ascertaining metacentric heights of a ship in any particular condition.

Determination of centre of gravity of a ship in any condition, the centre of gravity in light condition being given. Use of stability curves and data supplied to a ship. Alteration of stability during a voyage. Effect of shifting cargo Change of trim. (XVII , XVIII)

49. **Paper 5.** (Written) **Ship Maintenance, Routine and Cargo Work.** (3 hrs.)

(*a*) Keeping a ship's log. (Mate's log.)

(*b*) Ship maintenance and organisation. Indents and stores. Repair lists Properties and uses of paints Painting Chipping, scraping. Cement work Treatment of wood work. Inspection and maintenance of bulkheads, double bottoms, deep tanks, rudders. Bottom painting. Drainage of holds and double bottom tanks. Inspection and maintenance of anchors and cables Maintenance of holds with reference to cargo carrying. Spar ceilings etc Inspection and maintenance of pumps, strums, roseboxes and bilges.

(*c*) Simple calculation of stresses in spans, derricks, topping lifts, etc. Strength of ropes, chains, slings, two slings at an angle, etc. Purchases and power gained by purchases.

(*d*) *Cargo Work.*—(The candidate should, where possible, illustrate his answers from his own experience.)

Stowage of cargo General—stowage of bag cargoes, bales, casks, etc.

Bulk stowage. Partition and shifting boards. Ceilings and dunnage. Deck stowage. Possible damage and its avoidance.

Good and bad stowage. Special cargoes—explosives, grain, timber, oil in bulk, steel rails, etc.

Given a cargo list, to stow a hold or holds, making a rough cargo plan, with a view to stability of tender and stiff ships, damage and contamination, easy handling and possible optional ports of discharge.

Methods of ventilation of cargoes. Drainage of holds.

Closing of hatches Cargo working gear—derricks and winches. Organisation of cargo work. (III., VII., XII. to XVIII.)

51. **Oral Portion.**

1.—(*a*) Shifting large spars and rigging sheers.

(*b*) The handling of heavy weights with special reference to strength of gear used.

(*c*) Use and maintenance of all deck and above deck appliances and fittings—winches, capstans, windlasses, emergency steering gear, and fittings used between anchor and cable locker. Hoisting in boats.

(*d*) Bending, setting and taking in fore and aft sails. Management and equipment of ships' lifeboats and numbers of persons who may be carried in each class of boat. (III., IV., V., VI , VIII.)

2.—Anchors—different kinds; advantages and disadvantages of each. How to rig a sea anchor and what means to employ to keep a vessel, disabled or unmanageable, out of the trough of the sea and lessen her lee drift. Cables and their care. Preparations for anchoring. Operation of anchoring with single anchor and use of second anchor. Clearing a foul anchor. Mooring. Clearing a foul hawse. Anchoring in a tideway and in a confined space. Dragging anchor. Anchor watch. Slipping a cable. To carry out an anchor with boats. Getting under way. (VII., XIII.)

3.—(*a*) Effect of propellers on the steering of a ship. Stopping, going astern and manoeuvring. Turning circles. Effects of current wind sea, shallows, draft.

(*b*) Coming alongside a wharf, etc. Turning a steamship short round; manoeuvring in rivers and harbours Emergency manoeuvres. Man overboard.

(*c*) Management of steamships in stormy weather

(*d*) To get a cast of the deep sea lead. (VIII , XIII)

4.—(*a*) Testing life-buoys and life-jackets, other life-saving gear.

(*b*) Accidents, *e g* , collision, running aground, accidents to hatches, leaks, fires and their treatment. Running repairs Handling a disabled ship.

(*c*) A practical knowledge of the screening of ships' navigation lights

(*d*) Preparation for dry-docking Use of shores, bilge blocks and bilge shores. (VI , VIII , XI , XIII)

5.—*Regulations for Prevention of Collision at Sea.*—As par. 42, Section 5 (Oral), Second Mate (IX , X , XI)

6.—**Signals.**—As par 42, Section 6 (Oral), Second Mate. (XIX)

7.—The Examiner may ask the candidate questions arising out of the written work, if he deems it necessary on account of weakness shown by the candidate.

MASTER (FOREIGN-GOING).

55. **Paper 3.** (Written) **Ship Construction and Stability.** (3 hours.)

(*a*) The direction of simple ship repairs Drawing up of simple specifications

(*b*) A fuller knowledge of ship construction than in previous examinations. General structure—transverse and longitudinal girders, keels; stern frame, stem and rudder post, centre keelson, bilge and side keelsons; side stringers; tank margin, intercostals; transverse framing; shell plating; rudder propeller brackets, masts and derricks.

Classification of ships. Tonnage—measurement and registration. Freeboard.

Treatment of accidents and damage—collision, springing leaks.

Possible strains incurred by action of waves, improper loading or ballasting, etc.

Working of ship, division of loads.

(*c*) Stability diagrams and use of stability curves and information. Effect of beam and freeboard on stability. Practical operations to ensure ship stability at sea. Ship with a list. Management of ballast tanks. Effect of free liquid surfaces and risks of flooding hold spaces, filling and emptying tanks at sea. Suspended weights and shifting cargoes. Deck cargoes. Homogeneous cargoes. Ballasting. Effect of admission of water into interior of a ship. Flooded compartments. Stability and trim of a stranded ship. Trim—moment to change trim.

56. **Paper 4.** (Written.) **English.** (2 hours.)

This paper will test the candidate's ability to write clear and grammatical English, with good spelling and penmanship. It will be in no sense a test of technical or legal knowledge.

57. **Paper 5.** (Written.) **Ship's Business.** (2 hours.)

(The legal information required will not go beyond the outline of Mercantile Law which the shipmaster must know for practical purposes.)

(*a*) The official log and reports on exceptional entries.

(*b*) A shipmaster's knowledge of the law relating to:—

(1) Engagement, discharge, and management of a ship's crew. Ship's articles of agreement. Discipline and treatment of offences.

Wages and other remuneration Food and accommodation Entering and clearing the ship. National Insurance of crew

(2) Tonnage, life-saving appliances, salvage and assistance and, in general, the safety of ship, crew and passengers.

(3) Load line marks and entries and reports to be made respecting them. Surveys required by law.

(4) Hygiene of ships, living spaces, holds, etc. Water Fresh and preserved food. Infectious diseases The law relating to them and the procedure on board in such case. Quarantine procedure Recognition and simple treatment of common illness, *e.g*, fevers, etc. (See the *Ship Captain's Medical Guide.*)

(5) The carriage of emigrants.

(*c*) A simple knowledge of the law relating to cargo, including a knowledge of shipowners' liabilities in carriage of cargo.

(*d*) A general knowledge of shipping business and documents—charter parties, bills of lading, etc. A knowledge of average—general and particular. Flotsam and jetsam (XIX, XX.)

59 **Paper 7.** (Written.) **Engineering Knowledge.**

(Including Carriage of Refrigerated Cargoes.) (3 hours.)

(The requirements will not go beyond the knowledge that could be obtained by a deck officer who takes an intelligent interest in the machinery of the ship and supplements by a little reading what he has learnt in this way.)

(*a*) The meaning of general engineering terms, *e.g.*, horse power, slip and pitch of propeller, link, latent heat of steam, superheated steam, etc.

A general knowledge of a marine boiler and furnaces, and the procedure for raising steam. The general action of a reciprocating steam engine. Principle of the condenser. Distribution of steam from boiler to engines—valves and pipelines. Admission to engine—slide valves, eccentrics, expansion link. Starting gear. Simple description (without detail) of various parts of engines and boilers, *e g*, connecting rod, crank, piston and rings, packing of piston rods, relief valves and cylinder drains, line shafting, couplings, tail shaft, stern tube and packing. Auxiliaries and their uses—circulating pump, air pump, feed pump, bilge pump. Action of propeller. Thrust block. Attachment of propeller to shaft.

Oil fired furnaces and use of oil fuel. A simple knowledge of turbine machinery and of Diesel engines. Warming up and turning engines. Stopping and going astern—how done. A knowledge of what is required in the engine room on the receipt of manoeuvring orders from the bridge. Fuel consumption and economical speeds. Power and speed curves. Effect of alterations of speed on fuel consumption and estimation of adequacy of fuel to complete a given voyage.

(*b*) An elementary knowledge of refrigeration on board ship. Types of refrigeration on board ships. Types of refrigeration employed in special cases. Stowage and general handling of refrigerated cargoes.

60. Oral Portion.

1.—(*a*) Exceptional circumstances—loss of rudder; shifting a damaged rudder. Construction of jury rudders. Making and launching of rafts. Collision. Leaks. Damage of all kinds. Running repairs and precautions in case of accidents. Grounding—methods of refloating. Beaching a vessel Steps to be taken when disabled and in distress.

(*b*) Preservation of crew and passengers in the event of wreck. Abandoning a wrecked ship. Rockets and rocket apparatus. Communications with the shore.

(*c*) Assisting a vessel in distress. Rescuing crew of a disabled ship.

(*d*) Towing and being towed.

(e) Bad weather manoeuvres Precautions at anchor and at sea Use of oil

Anchoring and working anchors and cables in all circumstances. Approaching rivers and harbours and manoeuvring in them

(f) Drydocking General procedure and precautions to be observed Distribution of weight. Drydocking with full cargo for inspection of propellers or shafting Bilge beds. Leaving the vessel water borne. Putting into port with damage to ship and/or cargo, both from business and technical points of view Safeguarding of cargo.

(g) Prevention of fire at sea. Spontaneous combustion of fuel cargoes Full knowledge of the use of fire extinguishing appliance and precautions to be observed in cases of danger to life Special reference to extinguishing of oil fuel fires.

(h) Methods of fumigating holds and living spaces and safeguards in applying them.

(i) General organisation of ship's work and handling of crew.

2.—*Regulations for Prevention of Collision at Sea, etc.*—As par. 42, Section 5 (Oral), Second Mate

3.—*Signals.*—As par 42, Section 6 (Oral), Second Mate.

4—The examiner may ask the candidate questions arising out of the written work, if he deems it necessary on account of weakness shown by the candidate.

MATE (HOME TRADE).

80. **Oral.**

1. The content and application of the Regulations for Preventing Collision at Sea. Distress and pilot signals; penalties for misuse The use of the rocket apparatus. An intelligent use of "Notices to Mariners" (Candidates will not be required to commit these to memory.) (IX, X, XI)

2. Marking of ordinary lead line. The use and upkeep of mechanical sounding machines and logs. Construction and use of engine-room telegraphs. Anchor work; coming alongside; mooring and unmooring. Management of a ship's boat. (V., VIII., XIII.)

3. Understanding of bulkhead sluices, bilges, bilge pumps, water ballast tanks, sounding pipes and the ventilation of holds. Fire extinguishing appliances. (VIII., XVII)

4. An elementary knowledge of cargo work, as given in the syllabus for First Mate (Paper 5, Section *d*). (XVI.)

5. To read and understand a barometer and a thermometer. To use a sextant for taking vertical and horizontal angles and to find the index error. (VIII.)

Signalling.—British Semaphore up to 8 words a minute. Morse flashing up to 6 words a minute. International Code of Signals. (XIX.)

MASTER (HOME TRADE).

85. **Oral.**

1. International Regulations for Prevention of Collision at Sea and everything contained in Section 1 (Mate Home Trade). (IX., X., XI.)

2. Handling a ship in bad weather and when it is disabled. Preservation of crew and passengers in event of wreck. A fuller knowledge of mechanical sounding machines and logs Effect of screws on steering of a ship. (XIII.)

3. Understanding of effect produced by filling and emptying ballast tanks and loading and unloading cargo on the centre of gravity of the ship as a whole; the danger of free liquid surfaces in tanks and holds. (XVI., XVIII.)

4. A shipmaster's knowledge of the law relating to load line marks and entries and reports to be made respecting them. (XV)

5. To read and understand a barometer, thermometer and hydrometer. (VIII.)

Signalling.—As for Mate (Home Trade).

APPENDIX H.

Sea Service required to qualify for examination for Certificates of Competency

The following is a condensed statement of the sea service required to qualify in each of the various grades of Certificates of Competency. Where service as an officer is required it is shown in tabular form. The letter F is used as denoting foreign-going and H as denoting Home Trade· thus 1½ F in the first column of the table showing the officer's service for a First Mate's Certificate means 1½ year's service in foreign-going ships. Mate H in the last column means Mate of a Home Trade ship, and so on.

A candidate for sailing ship endorsement must show that at least 12 months of his service has been spent in square-rigged sailing ships.

CERTIFICATES FOR FOREIGN-GOING SHIPS.

Second Mate (Foreign-going).

Minimum age, 20 years. Minimum sea service, 4 F or 6 H.
No officer's service required.

First Mate (Foreign-going).

Minimum age, 21½ years. Minimum sea service, 5½ F or 8½ H.
Officer's service as follows.

Years.	Lowest capacity.	Lowest certificate required.
1½ F	Third of 3 watch-keeping officers	2nd Mate F
	or	
2½ H	Only Mate or First Mate	2nd Mate F

NOTE.—In certain circumstances service as Second Mate in the Home Trade may be accepted.

Master or Extra Master (Foreign-going).

Minimum age, 23 years. Minimum sea service, 7 F or 10½ H.
Officer's service as follows:—

Years.	Lowest capacity.	Lowest certificate required.
1½ F	First Mate - - - - - -	First Mate F
	or	
2½ H	Only Mate or First Mate - -	First Mate F
	or	
2 F	Second of 3 watchkeeping officers	First Mate F
	or	
1½	Second of 2 watch-keeping officers	First Mate F
	or	
2½ F	Third of 3 watch-keeping officers	First Mate F
	or	
3 H	Master - - - - - - -	Second Mate F or Master H for one year of such service

CERTIFICATES FOR HOME TRADE PASSENGER SHIPS.

The service required for these certificates may have been performed either in Home Trade or in Foreign-going ships.

Mate (Home Trade).

Minimum age, 20 years Minimum sea service, 4 years.
No officer's service required.

Master (Home Trade).

Minimum age, 23 years. Minimum sea service, 5 years,
Officer's service as follows —

Years.	Lowest capacity.	Lowest certificate required.
1 H	Only Mate - - - - -	Mate H or Second Mate F
	or	
2½ H	Second Mate *in charge of watch*	" "

Apply to any navigation school for information regarding temporary war time modification of sea service qualifications

MERCHANT NAVY TRAINING BOARD.

PRACTICAL SEAMANSHIP.

FIRST YEAR

Sailorising.—Learn to box the compass in points.

Different rigs of sailing boats and sailing ships. Types of steamers. Pages 1 to 6.

Whipping a rope; bends, hitches and knots; seizing and rackings; eye-splice and short splice; worm, parcel and serve. Pages 8 to 22, 611, 612.

Blocks, tackles, ropes and their uses. Spanish windlass. Pages 26 to 33.

The rigging of steamers. Page 49.

The names of the different kinds of lines and ropes in general use, the nature and materials of which they are made, the forms of their make, the uses to which they are put and the means to be adopted to ensure their long life. Pages 8, 49 to 65, 611.

Cargowork.—Draught marks on stem and stern posts. Load line marks Pages 372 to 385.

Length and size of strops, slings, belts and nets used in handling cargo. Pages 386 to 391.

Preparation of holds for cargo. Cleaning of bilges and clearing suction rose boxes. Closing and battening down hatches and gangway doors. Pages 398, 559, 604

Apparatus.—Handling and upkeep of patent logs and patent sounding machines. Marks on hand lead and hand log lines. Pages 124 to 140.

Statutory.—Learn to repeat the Articles of the Rule of the Road. Pages 183 to 205.

Signalling.—Signalling by Morse, semaphore. Flags of the International Code of Signals. Chapter XXII, page 617.

SECOND YEAR.

Sailorising.—Ship routine. Pages 1 to 5, 177 to 179.

Long splice in rope, eye-splice in wire. Safe working load of rope, wire and chain. Pages 20 to 25.

Seaming and roping palms, sewing canvas, awnings and tarpaulins. Different grades of canvas and their uses. Pages 62, 63.

Handling and management of boats under oars and sails Pages 66 to 82

Anchors and cables Pages 115 to 122, 543.

Cargowork.—Care and overhauling of cargo gear and its duration of life Dunnaging cargo and hold ventilation, necessity for dunnage and its proper use. Shifting boards and feeders. Mats and other means of separating parcels of cargo when such carried The need for and the preparation of cargo plans Pages 386 to 420.

Hold ventilation Pages 476, 478, 506

Maintenance.—Paint and paint mixing, quantity of paint required to cover various parts of the ship. Precautions taken to prevent rust forming on shell plating, on deck plating and in holds Use of cement and cement wash Pages 480 to 482, 613.

Statutory.—A full knowledge of contents and application of the Regulations for Preventing Collisions at Sea. Pages 183 to 235

Responsible Duties.—Duties with carpenter, boatswain and lamptrimmer.

Responsible (under an officer) for logs and lines, hand lead and lines and sounding machines

Responsible (under an officer) for gear of one boat and its readiness at all times for boat drill which must always be attended

On duty near an officer on all occasions entering and leaving port or anchorage and when shifting ship in port.

Night watches to be kept on the bridge.

A portion of some of the day watches at the wheel in fine weather away from land

Cleaning paintwork and brightwork. Rigging of stages, painting down masts and funnels and overside.

THIRD YEAR.

Sailorising.—Sending topmasts, gaffs and signal yards up and down. Bending, setting and taking in fore and aft sails. Fitting of rigging, turning in dead eyes and hearts. Use and overhaul of rigging screws, setting up of rigging, rattling down. Pages 49 to 65, 612.

Boat stations. Use of oil in bad weather. Lifeboat equipment, lifebuoys, lifebelts and their tests. Pages 82 to 114.

Maintenance.—Use and upkeep of engine room and other telegraphs. Pages 124 to 127.

Knowledge of use and maintenance of deck appliances and steering gear; different types of steering gear. Pages 157 to 164. Relieving tackles. Page 609.

Fire fighting appliances, their care and maintenance. Fire and boat drill. Pages 172 to 178.

Precautions to be taken with bad weather approaching, hatches, ventilators and lifelines. Precautions to be taken before nightfall. Page 607.

The nature of pigments, oils and varnishes used in ship work, together with explanations as to the reasons for using different types of paints, compositions and varnishes for certain parts of the ship. Bituminous compounds, their uses and reasons for same. Pages 480, 481, 613.

A portion of some of the day watches on the bridge in narrow waters.

Cargowork.—Tallying cargo. Mate's receipts, their value and need for accuracy. Protests, their meaning and value. Parcels of cargo liable to damage other cargo, precautions to be taken. Dangerous cargoes, stowage and precautions. Deck cargoes. Pages 386 to 420, 540.

Statutory.—Safety requirements under Factories Act as applied to ships. Pages 389, 559.

First Aid.

PRACTICAL SEAMANSHIP.

FOURTH YEAR.

Sailorising.—Launching of boats at sea and getting away from ship's side during heavy weather. Pages 83 to 92.

Sea anchors, types and uses. Ranging of chain cables in drydock Pages 119, 121, 331.

Keeping an anchor watch, dragging anchor. Duties of officer of watch. Pages 179, 298

Preparations and precautions for getting underway. Duties prior to proceeding to sea Pages 294, 305.

Precautions before entering, while in and before leaving drydock. Inspection of ship's under water parts in drydock Pages 339, 430, 615.

Cargowork.—The arrangements of derrick and cargo working gear. Rigging and working of heavy derricks Pages 45, 46, 55, 388.

Refrigerated cargoes. Pages 410 to 416.

Statutory.—Use of compass to ascertain risk of collision. Pages 210 to 213

Distress and pilot signals, penalties for misuse Notices to Mariners. Uniform system of buoyage. Rocket and line throwing apparatus Pages 236 to 254, 569, 570

Ship hygiene and fumigation. Pages 555, 556.

Signalling.—Morse, semaphore, International Code Flags of all nations Use of commercial code books Chapter XXII, page 617.

SHIP CONSTRUCTION.

FIRST YEAR.

Steel and wooden masts and derricks with their attachments and standing and running rigging and gear. Pages 49 to 56.

Deck sheathing and waterways. Pages 433, 437, 449.

Hatch coamings Hatchways and covers both wood and steel. Pages 457 to 460, 602, 603.

Sounding pipes. Air pipes. Pages 475, 476.

SECOND YEAR. (In addition to previous year.)

Local stiffening at ends of vessel and under boilers, engines, winches, windlass, etc. Pages 426 to 431.

Tank top plating. Plating of shell, bulkheads and decks. Pillaring and stanchion arrangements. Pages 438 to 457.

Rudders of various types. Pages 464 to 468.

Bilge and tank pumping arrangements. Pages 474 to 476, 604.

Carlin beams and partners. Page 602.

THIRD YEAR. (In addition to previous year.)

Names of the principal parts of a ship, *e g.* keel (bar and plate). Floors (solid and skeleton) and double bottom. Centre girder or keelson. Side and bilge keelsons. Pages 432 to 442, 597 to 601.

Stem bar, stern post, body post, stern frame, stern tube. Pages 460 to 474.

FOURTH YEAR. (In addition to previous years.)

A ship as a girder. Stresses a ship has to resist, longitudinal, transverse, collapsing, local. Pages 426 to 432.

Longitudinal and transverse systems of framing. Beams and beam knees. Stringers and stringer plates and methods of attachment of the various parts. The construction of the cellular double bottom with its various members. Pages 433 to 442, 471, 478, 597 to 601.

Names of the various types of rivets and reasons for these. Pages 444 to 446.

Parts of a ship particularly liable to corrosion and methods of dealing with it in peaks, bunkers, double bottom tanks, etc. Pages 480, 481, 613.

SPECIAL TYPES OF SHIPS FOR SPECIAL CARGOES.

The following section is inserted as it is necessary that an apprentice's knowledge should not be confined to the type or types of vessels upon which he happens to have served.

Timber Carriers.—Deck loads and methods of securing Pages 408 to 410

Tankers.—General arrangement of ship and tanks and cargo arrangements, pipes and valves; precautions against admixture of cargo Pages 416 to 420

Refrigerated and Insulated Ships.—General elementary principles of refrigeration. Different temperatures for different cargoes, such as chilled meat, frozen meat, dairy produce and various kinds of fruits. General elementary principles and methods of insulation Pages 410 to 416, 607

Load Lines Generally.—Special load lines for tankers and timber laden ships and reasons for variation. Pages 476 to 480.

MISCELLANEOUS KNOWLEDGE.

FIRST YEAR.

Knowledge of simple machines, *e.g.* tackles, meaning of mechanical advantage, strength of rope, wire and hemp. Pages 26 to 40.

Resolution of forces. Action of forces on a derrick. Pages 263 to 276.

Centre of gravity; simple examples Moments of the forces as applied to levers, capstan and winches Pages 488 to 500.

Hydrometer and its use. Specific gravity. Buoyancy. Pressure in liquids; variation with depth and application to sounding machines. Pages 359 to 372.

Flotation and its application at sea. Use of load lines. Pages 372 to 385.

SECOND YEAR.

Construction of a thermometer. Meaning of temperature. Centigrade, Absolute, Fahrenheit and Reaumur scales, conversion from one to the other maximum and minimum thermometers. Absolute zero. Pages 147 to 150.

The marine barometer, aneroid barometer, barograph. Construction of a barometer. Measurement of air pressure, units, *e.g* bar, millebar. Pages 147 to 152.

Air pressure. Variation of air pressure with height and latitude.

The atmosphere and its humidity. Vapour pressure and dew point; the wet and dry bulb hygrometer and its principles and uses. Page 151.

Boyle's and Charles's Law.

Reflection of light by plane mirrors. Effect of reflection by rotation of mirror as in the sextant. Sextant errors and their correction *Guide*, Vol I., pages 298 to 311.

Refraction of light by azimuth mirror. *Guide*, page 179. Atmospheric refraction. *Guide*, page 315.

Formation of images by lenses Magnification of a telescope.

THIRD YEAR.

Definition of "metacentre" and "metacentric heights." Stiff and tender ships. Pages 403, 501 to 506

Plotting T P.I. and displacement curves. Calculation of displacement using a block coefficient. Tons per inch calculations. Deadweight scales. Pages 509 to 515.

Effect of filling and emptying ballast tanks on centre of gravity as a whole. Estimating weights of simple parts of ship's structure. Displacement and sinkage of box forms. Centre of buoyancy and centre of flotation. Pages 515 to 530.

FOURTH YEAR.

Recapitulation for second mate's examination.

ENGINEERING KNOWLEDGE.

The purpose of this subject is not to provide an apprentice with a detailed knowledge of engineering, but to enable him to appreciate the functions of the various engineering appliances on board ship in a simple manner.

The textbook, *Engineering for Nautical Students*, by W. A. Fisher, A.M.I.Mech.E., A.R.T.C., has been written to meet the requirements of this Syllabus. Published by Brown, Son & Ferguson, Ltd., Glasgow, price 7/6.

FIRST YEAR

Use of instruments and scales

The sketching of such objects as nuts, bolts, rivets and simple engine parts, *e g.* a winch piston, a stop valve, a connection rod for a small engine.

Drawing in plan and elevation

How drawings are dimensioned.

Practice in this work by making a dimensioned sketch from a given object.

Simple ideas of the working of a reciprocating engine, *e g* winch; names of essential parts and method of lubrication.

How a steam windlass works. Differences between gear wheels and worm gear

Simple ideas on the general construction of marine boilers

How to operate a steam valve. How pipe lines are drained Danger of frost on pipe lines and winch cylinders

How steam is produced in a steam boiler. How it works the engine.

SECOND YEAR.

Steering gears, their types and the various means of operation.

The various pumps on board ship, *e.g.* feed, ballast and bilge, and how they are worked.

The pipes and valves for pumping out bilges, ballast and oil tanks

The shafting from engine to propeller and the means by which the thrust of the propeller is transmitted to the hull of the ship.

How coal and oil are burned in the furnace of a marine boiler.

Danger of fire and the means of preventing, detecting and extinguishing it

How a refrigerating machine works; the importance of insulation; how the chambers are cooled.

Simple idea of how a steam turbine works.

Simple idea of how a Diesel engine works.

THIRD YEAR.

How electrical pressure, current and resistance are measured. Ohm's law. Some idea of the size of the units by reference to ships' lighting and power supply. Dangerous voltages (dry and wet body).

What a current of electricity can do: simple ideas of magnetic, heating and chemical effects.

Heating effect of a current—how it increases with an increase in the strength of the current. Melting of substances: effect of temperature upon conducting and insulating properties of substances. How insulated cables tend to insulate heat and so raise temperature. Fuses.

Primary and secondary batteries. Care and use of accumulators. Electrical corrosion.

Why a ship's supply must have a constant pressure Building up a simple lighting circuit. What candle power is—how C.P. depends upon electrical power—how it varies in different types of lamps—how lamps are rated. Lamps in series and in parallel.

How an electro-magnet works. the electric bell and buzzer, telephone, microphone and moving iron ammeter.

How a D.C electric motor works. Application in the construction of moving coil ammeter.

Simple ideas of the principle and construction of a dynamo. The spring cut-out as safety device Direct and alternating current. The transformer.

Different types of motors used in ships: the functions of the starter.

Electrical heating and lighting appliances found aboard ship. The measurement of energy in watts, Board of Trade units: the relation of watts to horse-power.

Simple ideas on the main parts of a ship's wireless apparatus.

MARINERS' COMPASS

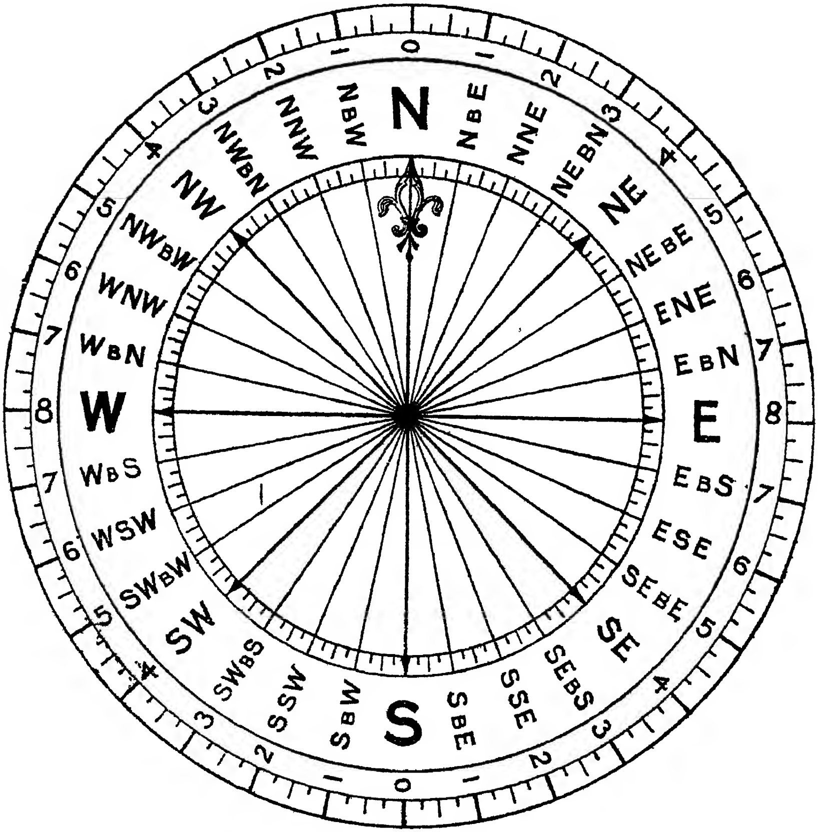


TABLE OF THE ANGLES.

Pts.	°	′	″	Pts.	°	′	″	Pts.	°	′	″	Pts.	°	′	″
¼	2°	48′	45″	2¼	25°	18′	45″	4¼	47°	48′	45″	6¼	70°	18′	45″
½	5	37	30	2½	28	7	30	4½	50	37	30	6½	73	7	30
¾	8	26	15	2¾	30	56	15	4¾	53	26	15	6¾	75	56	15
1	11	15	0	3	33	45	0	5	56	15	0	7	78	45	0
1¼	14	3	45	3¼	36	33	45	5¼	59	3	45	7¼	81	33	45
1½	16	52	30	3½	39	22	30	5½	61	52	30	7½	84	22	30
1¾	19	41	15	3¾	42	11	15	5¾	64	41	15	7¾	87	11	15
2	22	30	0	4	45	0	0	6	67	30	0	8	90	0	0

NICHOLLS'S

SEAMANSHIP AND NAUTICAL KNOWLEDGE

Nicholls's Seamanship and Nautical Knowledge

CHAPTER I.

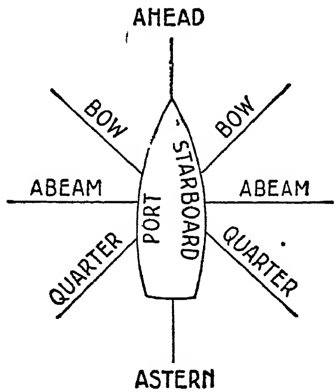
SEAMANSHIP is the work of the seaman on board ship. A vessel is organised into three departments, deck, engine and cabin, the members of each department being all referred to as seamen in the Merchant Shipping Act, but our work refers to the duties of the deck executive. Seamanship and navigation are different branches of nautical work; a seaman, for example, need not be a navigator but a navigator must needs be a seaman.

Formerly, in the days of sail, seamanship included the maintenance of standing and running gear and the manipulation of all the vessel's paraphernalia of yards, sails and cordage in manoeuvring the sailing ship by applying, in a rough and ready but very practical manner, the principles of mechanics to the propulsion of the wind-driven ship and the operation of manual machines.

The sailing vessel as a commercial proposition so far as Great Britain is concerned has passed away and much of the knowledge peculiar to her equipment is now obsolete. But seamanship of a somewhat different and perhaps of a more comprehensive character is required from officers of the modern steamship. The sea has not altered nor have the fundamental nautical principles, but the ship herself has undergone radical change, the methods of propulsion equipment, communication, maintenance and control have altered so much that a different kind of knowledge and handcraft is now required from the seaman who aspires to executive position.

The development of sea transport has called up much legislation in the interests of life and property at sea, and a knowledge of statutory regulations relating to what may and may not be done in many diverse ways regarding structural detail, the equipping and handling of the ship, the loading of cargoes, rule of the road and other compulsory safeguards, form a large part of a seaman's duty and call for understanding and a sense of responsibility.

It is convenient sometimes when indicating roughly the direction of an object external to the ship to divide the horizon into sectors relative to her fore-and-aft line. An object may be reported as being ahead or astern, on starboard bow or port bow, on starboard beam or port beam, starboard quarter or port quarter.



Thus the white masthead lights show from right ahead to two points abaft the beam on each side; the green side-light shows from right ahead to two points abaft the starboard beam; the red side-light from right ahead to two points abaft the port beam; the white stern light from right aft to two points abaft the beam on each quarter.

The Lookoutman is stationed on the forecastle-head or in a crows-nest on the foremast and, like the man at the wheel, he usually does a two hours' "trick." When the lookoutman sights a light on the starboard bow he usually intimates the fact by one stroke on the bell, two strokes for a light on the port bow, and three strokes when it is sighted right ahead. He may supplement this signal by calling out the fact to the officer on the bridge.

The Day at Sea is divided into watches of four hours each, viz., from midnight to 4 a.m., 4 to 8, 8 to 12, 12 to 4 p.m., then two "dog watches" 4 to 6 and 6 to 8 to break the sequence and then 8 p.m. to midnight. The dog watches are only necessary in the watch and watch system, four hours on deck and four hours below.

Bells are struck every half-hour in each watch, an additional stroke for every successive half-hour; thus four bells in the middle watch at 2 a.m., six bells at 3 a.m., seven bells at 3·30 and eight bells at 4 o'clock.

The watches are changed at eight bells and the same sequence of half-hourly bells repeated. The watch below is called fifteen minutes before eight bells, and it is a habit of disciplinary nautical etiquette to relieve the watch on deck promptly on the stroke of eight bells. Formerly, the watch and watch system was universal and it is still the usual routine for deck hands, except on ships where quartermasters are specially engaged to steer the ship, in which case the deck hands are usually on whole day work, each man taking a turn on the lookout at night. The officers, however, are organised in three watches, the chief officer taking the 4 to 8 watch morning and evening, the third officer the 8 to 12 watches, and the second officer the middle and afternoon watches from midnight to 4 a.m. and noon to 4 p.m.

Helm Orders.—The rudder in very small ships is turned by a helm or tiller as in the life-boats. The helm has disappeared from ocean-going ships but the name still survives and only the rudder remains the same. When it is desired to turn the ship's head to starboard, the rudder is angled to starboard by turning the steering wheel so that its upper half also turns to starboard; conversely, when the ship's head is turned to port, the rudder is angled to port by turning the wheel so that its upper half also turns to port, all of which sounds quite intelligible and logical. The word helm for some unexplained reason is still retained and the Board of Trade has intimated that "*from 30th June,* 1931, *helm or steering orders to the steersman shall be given in the direct sense, e.g. when the ship is going ahead an order containing the word 'starboard' or 'right' or any equivalent of 'starboard' or 'right' shall only be used when it is intended, on ships as at present generally constructed and arranged, that the wheel, the rudder-blade and the head of the ship, shall all move to the right.*"

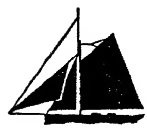
This recommendation also forms the text of Article 41 of the International Convention (1929).

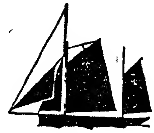
We have purposely avoided using the word helm in this book and have referred to the action of the rudder direct which, after all, is the apparatus that causes the ship to turn.

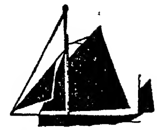
Conning the Ship.—When the command is given "port 10°" the man at the wheel replies in a responsible manner "port 10°, sir," and then turns the wheel until the indicator on the steering wheel pillar comes to "port 10°," the rudder is then at an angle of 10° with the line of the keel and the ship's head will turn in response to the action of the rudder. In some ships the order "port 10°" would mean steer 10° to port of your course. The order may be "hard-a-port" or "hard-a-

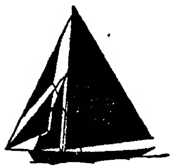
SAILING SHIP RIGS.

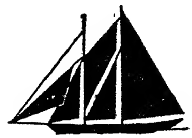

Cat-boat Sloop

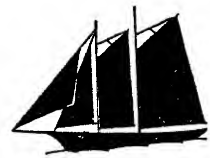

Cutter

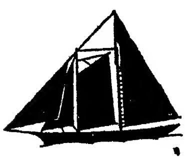

Ketch

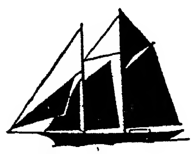

Yawl

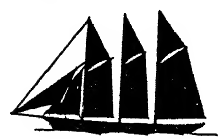

Sloop

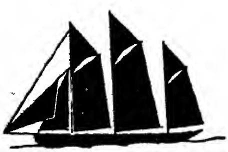

Staysail Schooner

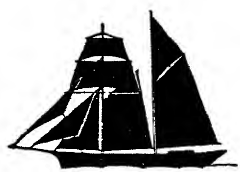

Polemast Schooner

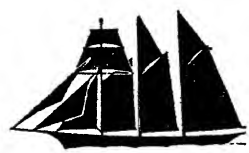

Schooner (Jib-headed mainsail)


Fore-and-aft Schooner


3-mast fore-and-aft Schooner

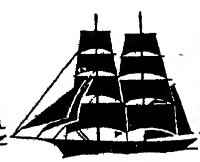

Schooner Ketch


Topsail Schooner

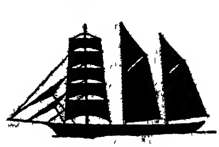

3-mast Topsail Schooner

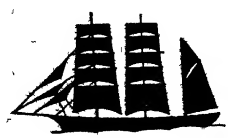

Half-Brig

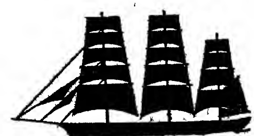

Brigantine


Brig


Hermaphrodite Brig


Barquentine


Barque


Ship

starboard," whereupon the wheel is turned in the required direction until it can go no further Incidentally, it may be remarked that the angle of maximum turning efficiency of the rudder is about 35 degrees. When the ship's head is swinging the officer may order "ease the helm" to which the quartermaster at once replies "Ease the helm, sir" and brings the wheel back a few turns. But should the order be a peremptory "Steady" the quartermaster replies "Steady, sir," and notes the direction of the ship's head at the time by the compass, or by an object in sight ahead of the ship and steers straight for it. All steering orders are repeated by the man at the wheel in a clear, responsible manner.

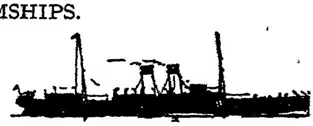
When the wheel is relieved at sea the man going off steadies the ship on her course and announces the course distinctly to his relief man, who repeats it when taking over. The man going off duty reports the course to the officer of the watch, who repeats it and then makes sure the new man at the wheel is steering the proper course.

Sailing Ship Rigs.—It is still essential to be able to recognise sailing vessels by their rig if only for reporting intelligently about them when sighted at sea. On page 4 the silhouettes give an indication of their general outlines.

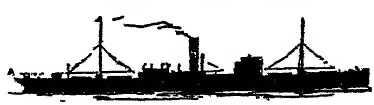
Types of Steam Vessels.—Steam vessels also have their characteristic features, probably more varied than sailing ships ever were, and seamen can often identify ships belonging to particular companies by little peculiarities in their general outlines, the rake and positions of their funnels and masts, the arrangement of deck erections, etc., long before they are near enough to distinguish the colours and markings of funnels and hull, assisted, no doubt, by a knowledge of their trading routes. We give here a few silhouettes of distinctive types of ships.

TYPES OF STEAMSHIPS.

A "Three Island" Ship



A Cross Channel Steamer

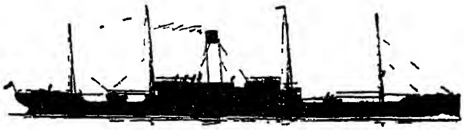


A Flush Deck Ship

A Tanker

A "Goal Poster"

A Motor Ship



A "Four Master"

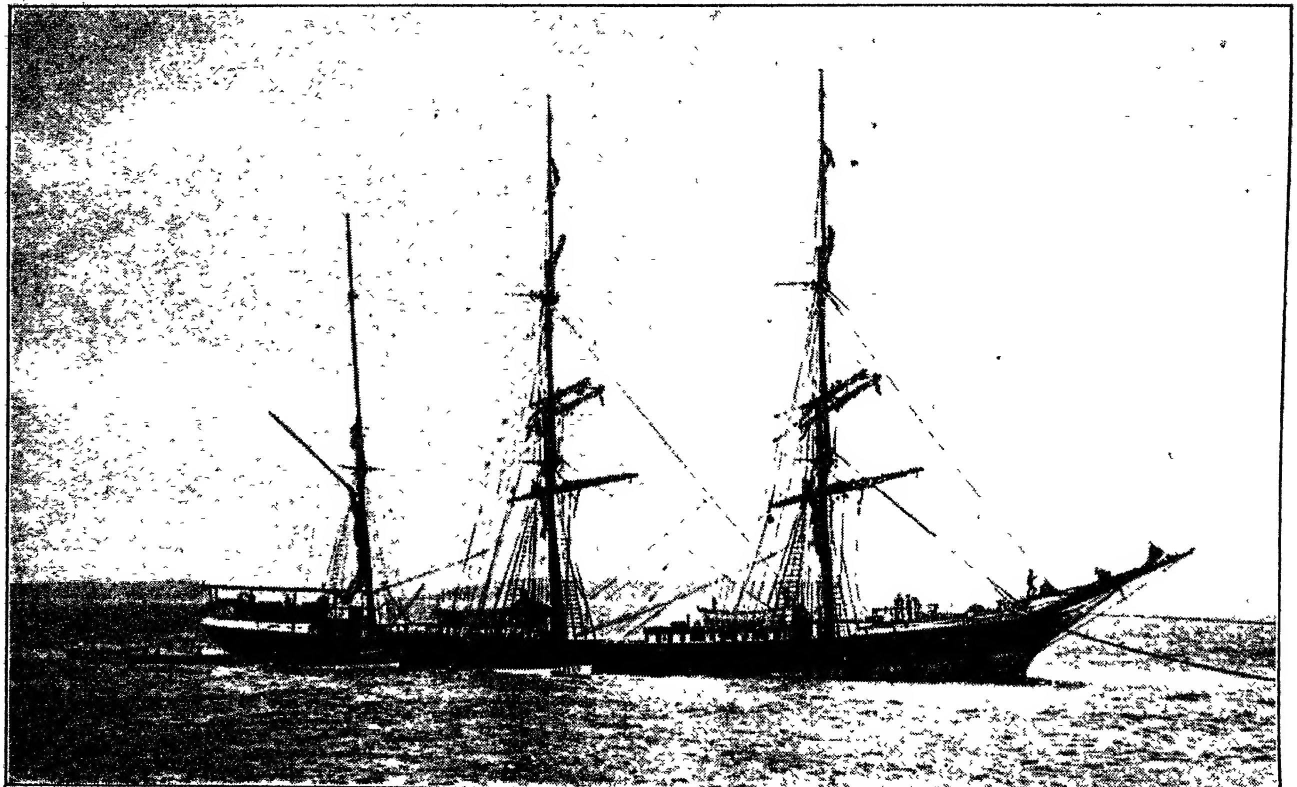
A Distinctive Type

A "Raking" Stem

A Canadian Passenger Liner

A Colonial Trader

A Cape Liner



Barque *Queen Mab.* Launched 1887. Torpedoed and Sunk 1917.

CHAPTER II

KNOTS, BENDS, SPLICES

The Construction of Ropes

ROPE, the term being used in its widest construction, is made from almost every pliable material, but is generally composed of hemp, manila, coir, cotton, steel, iron, or copper wire. *See* page 611.

For the present we will confine ourselves to those having their origin in the vegetable kingdom, and more especially to those made from hemp and manila.

These are divided into three classes:—

(1) **A Hawser-laid Rope**, which is composed of three strands laid up generally right-handed (that is, the direction taken by the strands in forming the rope runs always from left to right) (Fig. 1).

(2) **A Shroud-laid Rope**, also laid up right-handed, but consisting of four strands with a heart in the centre (Fig. 2).

(3) **A Cable-laid Rope**, which is composed of three right-handed hawser-laid ropes laid up together left-handed, so that it may be said to consist of nine strands (Fig. 3). See also page 612.

Fig. 1.

Fig. 2.

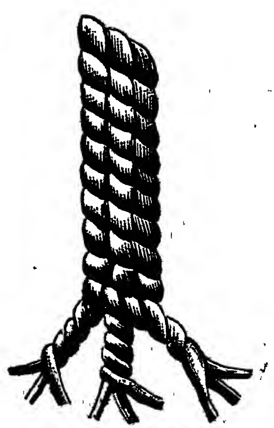


Fig. 3.

(1) **Whippings.**—The end of a rope must always be secured in some way, or it is evident from its construction that it will, on the slightest usage, become frayed out The commonest method is by working on an ordinary whipping, which is done as follows:—First lay the end of a length of twine along the end of the rope, and then commencing at the part furthest from the rope's end take a half dozen or more turns around both the rope and twine end (Fig. 4). Then lay the twine in the form of a loop along the rope and over the turns already taken, as in Fig. 5. To finish off take that portion of the loop designated *a*, and continue taking turns tightly round the rope and part *b* of the twine until the loop is nearly all used up; pull through the remainder snugly by part *c*, and cut off short when no end of twine will be visible as in Fig 6.

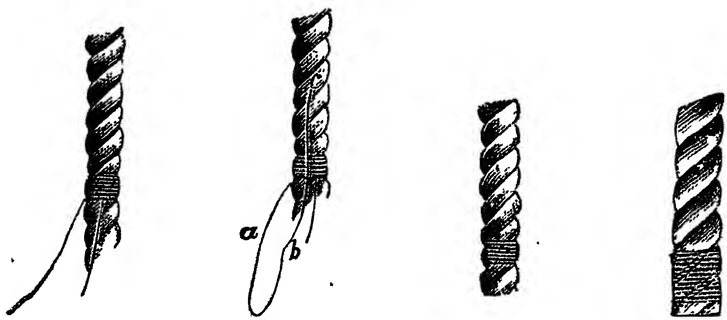


Fig. 4. Fig. 5. Fig. 6. Fig. 7.
Whippings.

(2) **A Palm and Needle Whipping** (Fig. 7) is a more permanent way of securing a rope's end from fraying than the common whipping put on by hand. First, place the needle under one of the strands and draw nearly the whole length of twine through. Take a considerable number of turns round the rope with the twine, drawing each well taut in turn, and finish up by following round with the needle between each strand, forming a series of frappings, and cut off the end of the twine short.

(3) **A West Country Whipping** is formed by middling the twine around the part of the rope to be marked and half knotting it at every half turn, so that each half knot will be on opposite sides. When a sufficient number of turns are passed, finish it off with a reef knot.

Considering that we now have at our disposal a small sized rope with the end whipped, we will at once proceed to the formation of the most elementary knots and hitches, namely, those formed by a single rope's end.

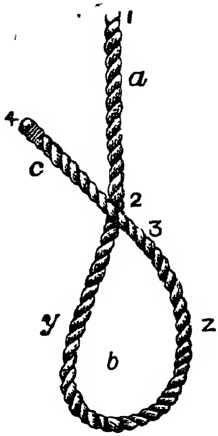


Fig. 8.
A Bight.

Fig. 9.
Overhand Knot.

Fig 10.
Figure-of-Eight.

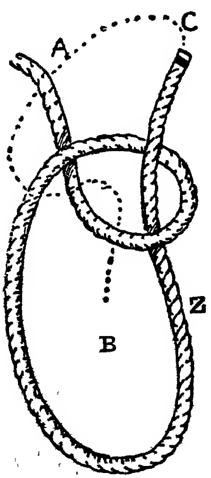


Fig. 11.

Fig. 12.

Bowline.

A Common Loop, by which most of the following knots, etc., are commenced. Note exactly how the loop lies, and let us letter its parts clearly for future reference. The part of rope extending from 1 to 2 is known as the standing part which we will call *a*, the portion included between 2 and 3 following round the loop by *y* and *z* is termed the bight which we will call *b*, and from 3 to 4 is known as the end *c*.

Then starting in each case from the position shown in Fig. 8 we make the following knots, etc.:—

An Overhand Knot.—Place *c* up through bight *b*, and draw taut.

A Figure-of-Eight Knot.—Back *c* round behind *a*, bring over part *z* and dip down through bight *b* and haul taut.

A Bowline.—Reverting to our original loop first taking part *z* in the right hand with *y* in the left, throw a loop over *c*, the end.

Secondly, lead *c* round behind part *a* and pass it down through the last made loop, as indicated by the dotted line, and haul taut as in Figure 12.

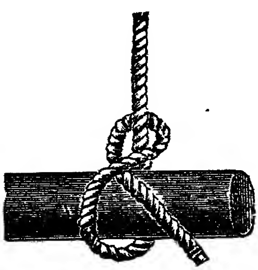


Fig. 13.

Fig. 14.

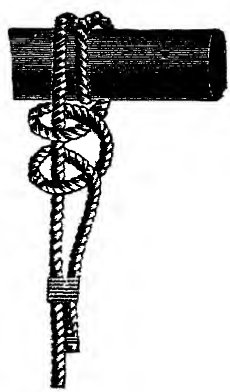


Fig. 15.

Half Hitches.

The formation of a half hitch (Fig. 13), and two half hitches (Fig. 14) is sufficiently indicated by those diagrams.

The commonest method of making a rope's end fast to a bollard, etc.,

is by taking a round turn and two half hitches, and stopping the end back for further security (Fig. 15).

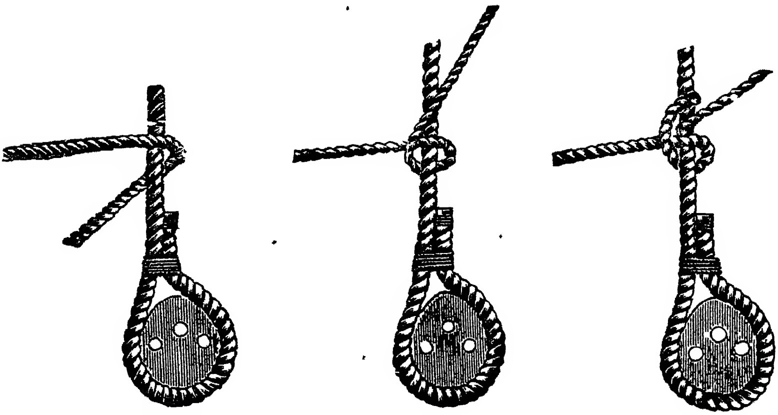


Fig. 16. Fig. 17. Fig. 18.
Clove Hitch.

A Clove Hitch is really a jamming form of two half hitches, and is principally used when a small rope has to be secured to a larger one and the end still kept free to pass along for further purposes, as in securing ratlines to the shrouds. Its formation is shown in three successive stages (Figures 16, 17, 18).

A Rolling Hitch is commenced and finished like a clove hitch, but as will be seen from the three diagrams (Figs. 19, 20, 21), illustrating its construction, there is an intermediate round turn between the first

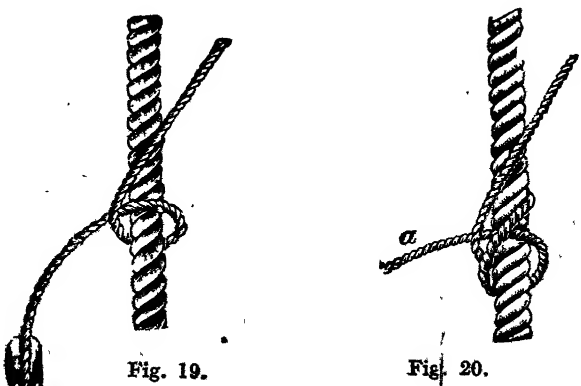


Fig. 19. Fig. 20.

Rolling Hitch.

and last hitches. It is principally used for securing the tail of a handy billy or snatch block to a larger rope, or when hanging off a rope with a stopper.

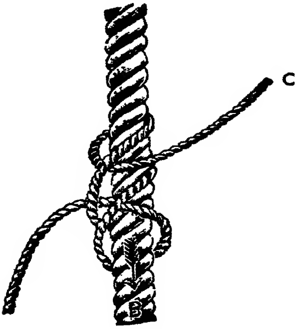


Fig. 21. Rolling Hitch. Fig. 22.

Note that the round turn in Fig. 20 is taken round both the standing part *a* and the larger rope. The great value of this hitch is its non-liability to slip in the direction *B* (Fig. 21). If, however, owing to an extremely severe strain or other causes the hitch is inclined to slip, the end *c* should be backed round part *d* of the first rope, that is, twisted around it in long lays in the opposite direction to that in which the hitch was formed, and the end secured by a stop (Fig. 22.)

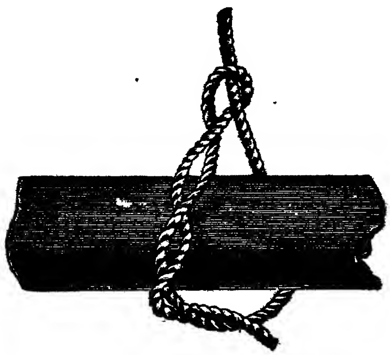


Fig. 23.—Timber Hitch.

A Timber Hitch is a useful way of securing a rope quickly to a plank, but when there is to be a long and continuous strain, or when it is required to keep the end of a piece of timber pointed steadily in one direction, it should be supplemented with a half-hitch (Figs. 23, 24.)

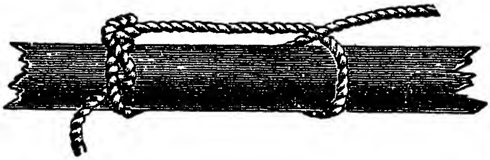


Fig. 24.

The timber hitch itself consists simply of a half hitch taken with a rather long end, which is used up by twisting it back around its own part of the hitch. The hitch is purposely left very loose so that its formation may be the more easily seen in the illustration (Fig. 23).

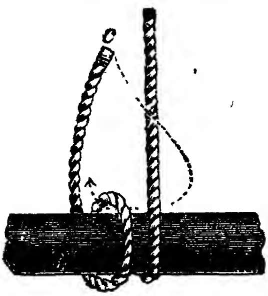


Fig 25.

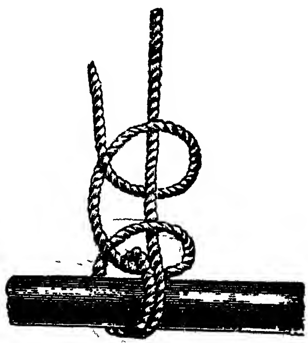
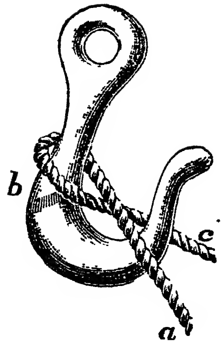


Fig. 26.

Fisherman's Bend.

A Fisherman's Bend is formed by taking two round turns around the object to which the rope is to be secured, and then backing the end round in the form of a half hitch under both the standing part and second round turn. The end may be further secured by taking a half hitch around its own part or by stopping it to it (Figs. 25, 26), the dotted line showing the next direction the end *c* must take.

A Blackwall Hitch is a quick way of temporarily securing a rope to a hook. As will be seen from the illustration (Fig. 27) it consists of a half hitch, the standing part *a* as soon as it receives the strain jamming the end part *c*. It holds much more firmly than would be imagined at first sight By taking another round turn at *b*, before passing the end *c* under *a*, it will hold more securely.



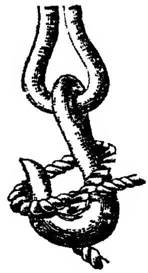
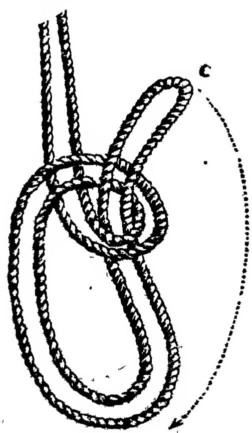


Fig 27. Fig. 28. Fig. 29.

Blackwall Hitch.

A Midshipman's Hitch is sometimes used instead of a Blackwall hitch, and will hold better if the rope is at all greasy. It is made by first forming a Blackwall hitch and then taking the underneath part and placing it over the bill of the hook (Fig 28).

A Double Blackwall Hitch is made by taking the bight of the rope and placing it across the neck of the strop of the block, crossing it behind, then placing the under part over the hook and crossing the upper part on top of it. It holds better than either of the two preceding hitches (Fig 29)



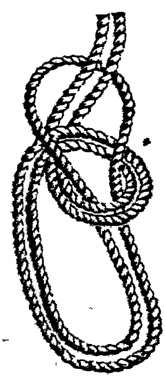


Fig 30. Bowline. Fig. 31.

A Bowline on the Bight—Using both parts of the rope together,

commence as in making an ordinary bowline (Fig. 30). To finish o
open out bight *c*, and taking it in the direction indicated by the dott
line, pass the whole knot through it and haul taut, when it w
appear as in Fig. 31.

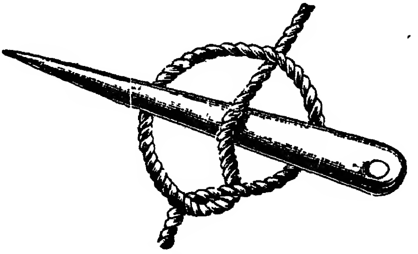


Fig. 32.

A Marline-spike Hitch is used for getting a purchase with a marlin
spike, capstan bar, etc., when putting on a seizing or lashing. It wi
be seen to consist of the standing part picked through a loop laid ov
it, so that the spike lies under the standing part and over the sides c
the loop.

A Sheepshank is used for shortening a rope. Gather up the amoun
desired in the form of Fig. 33. Then with parts *a* and *b* form a half hitc
round the two parts of the bight as in Fig. 34. To render it still mor

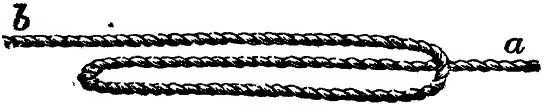


Fig 33.

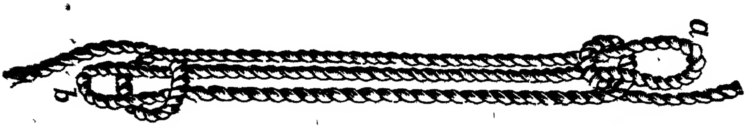


Fig. 34.

Fig. 35.

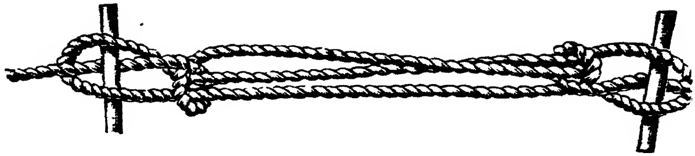


Fig. 36 —Sheepshank.

dependable the bight *a* and *b* may be seized or toggled to the standing part as in Figs. 35 and 36.

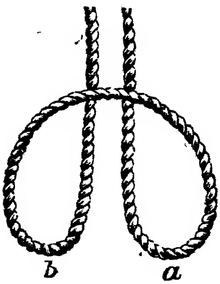


Fig. 37. Catspaw. Fig 38.

A Catspaw is formed in a rope to make a temporary loop for hooking on the block of a tackle. First throw back a bight as in Fig 37.

Then taking hold of *a* and *b* in either hand twist them up as in Fig 38; bring together the two eyes *a* and *b* and hook in the tackle.

KNOTS, BENDS, AND HITCHES FOR UNITING ROPES.

A Reef Knot.—The simplest of all knots, and is always used when a common tie is required. Its formation may be easily traced in Figs. 39, 40, 41. Having constructed the knot as far as Fig. 39, be sure part *a* is kept in front of part *b* as here shown, and the end *c* led in according to the direction of the dotted line.

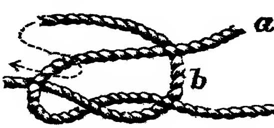


Fig. 39. Fig. 40. Fig. 41.

A Common Bend or Sheet Bend.—In making a bend the ends of the two ropes are not used simultaneously as in forming a reef knot, but an

eye or loop is first formed in the end of one of the ropes as in Fig. 42 and the other rope's end is then rove through it in various ways according to the bend desired.

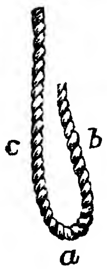


Fig 42

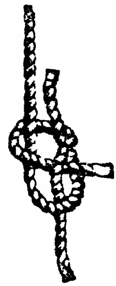


Fig. 43.
Sheet Bend.

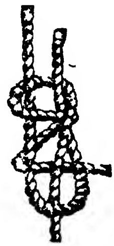


Fig. 44.

To form a Sheet Bend, pass the second rope's end underneath the eye at point *a* and bring up through the loop, then form with it a half hitch round *c* and *b* (Fig. 43).

It will hold still better and is less likely to jamb if the end *c* is passed round again as in Fig. 44.

Carrick Bend.—For bending two hauling lines together use a **Carrick Bend.** First form with hawser No. 1 a loop as in Fig. 45.

Fig. 45.

Carrick Bend.

Fig. 46.

A Spanish Windlass.—To rig a Spanish Windlass (Fig 50) take a good strand well greased in the centre. Place the strand over the two parts of the rope that are to be rove together, and bringing the ends of the strand up again place a bolt close to the strand Take the ends of the strand and lay them up with their own parts so as to form two eyes. Take a round turn with this round the bolt, put a marline-spike through each eye and heave around.

SPLICES.

An Eye Splice is formed by unlaying the end of a rope for a short distance, and then, after closing up the end, to form an eye of the desired size Lay the three strands upon the standing part, now tuck the middle strand through the strand of the standing part of the rope next to it against the lay of the rope (Fig. 51), then pass the strand on the left over the strand under which No. 1 strand is tucked, and tuck it under the next (Fig. 52), and lastly, put the remaining strand through the third strand on the other side of the rope as in Figs. 53 and 54.

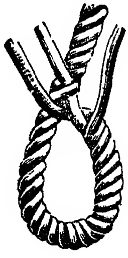


Fig 51.


Fig 52

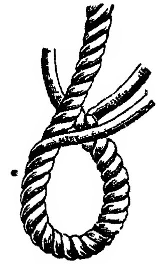


Fig. 53.


Fig. 54.

Now tuck each strand again alternately over a strand and under a strand of the rope, and then taper off by halving the strands before tucking the third time, and again halve them before the fourth tuck.

If the strands are tucked with the lay of the rope it is termed a Sailmaker's Splice.

A Short Splice is used to join two ropes when it is not required to pass through a block. Unlay the two ropes the required distance, and

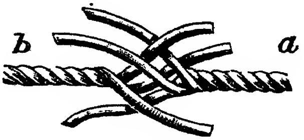


Fig. 55.

clutch them together as in Fig. 55, that is, so that the strands of one rope go alternately between the strands of the other

Then tuck the strands of rope *a* into the rope *b* in a similar manner to that described in an eye splice and similarly tuck the strands of *b* into *a* (Figs. 56 and 57).

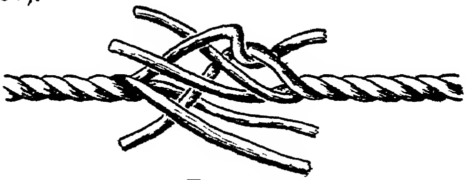


Fig. 56

Fig. 57.

A Long Splice is one of the most useful of splices, as it permits the rope to run through a block just the same as an unspliced rope.

Unlay the ends of two ropes to a distance about four times the length used in a short splice, and then clutch them together as if about to commence a short splice. Now unlay one strand for a considerable distance and fill up the gap thus caused by twisting in the strand opposite to it of the other rope. Then do the same with two more strands. Let the rema ning two strands stay as they were first placed. The ropes will now appear as in Fig. 58.

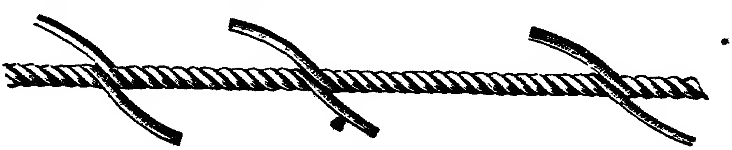


Fig. 58.

To finish off, tuck the ends as in a short splice, but *with* the lay of the rope, that is, so that the tuck will continually take place around the same strand, and taper off gradually by reducing the yarns in the strand.

To Make a Grommet, cut a strand about three and a half times the length of the grommet required. Unlay the rope carefully and keep the turns of the strand in. Close up the strand in the form of a ring (Fig. 59), and then pass the ends round and round in their original lay

until all the intervals are filled up (Fig. 60), and then finish off the two ends as in a long splice (Fig. 61).

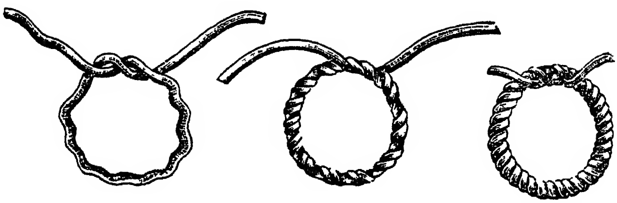


Fig 59. Fig 60. Fig 61.
A Grommet.

WIRE SPLICING.

In splicing wire, great care should be taken to prevent kinks getting in the rope or strands.

With steel wire, always before working it, put a stop on at the place to which you intend to unlay, and also put a good whipping of twine at the end of each strand.

Steel wire is six-stranded right-handed, and has a heart of hemp. Flexible wire has a heart of hemp in each strand.

Crucible wire is made in the same manner, except that the strands are wire throughout.

Crucible wire is used for standing rigging and flexible wire for purchases, etc.

In splicing wire all tucks are made with the lay of the rope.

In making an eye splice the rope is handled better if hung up in a convenient position so that when standing up the eye will be at about the level of the chest of the person working.

A long tapering steel marline-spike is required, and after placing it under a strand do not withdraw it until the tuck is made and all the slack of the strand drawn through.

There are several methods in vogue for tucking the strand, but the following is as good as any:—Tuck the first strand under two strands and all the rest under one strand respectively. Tuck whole again, and this time each strand under one strand, then halve the strands and tuck again.

To make a neat splice do not haul the part of the rope that has not been unlaid too close to the neck of the splice, and in tucking the strands never take a short nip but take long lays.

In unlaying for a long splice, always unlay two strands simultan-

eously, to keep the rope in its original lay. For a fair-sized rope unlay about 9 ft. of each end.

Proceed as in rope splicing, and after the three pairs of strands are in their places, single them, and continue to unlay and lay-in until the six meeting places of the strands are equidistant.

To finish off the ends properly can only be learnt by observation and actual practice. By using two marline-spikes, the hempen heart is removed and the ends of the wire strands forced into the place it occupied making a very neat job when finished

Wire splices should be parcelled with oily canvas and served with Hambro' line

Splicing Thimbles—Under and Over Style.—Ordinary type of wire rope. Serve the rope with wire or tarred yarn to suit the circumference

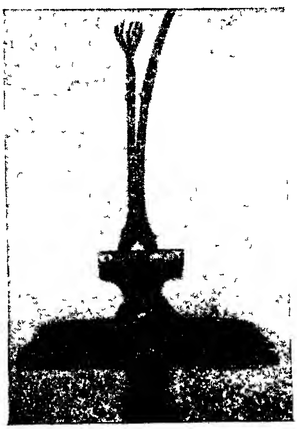


Fig. 62.

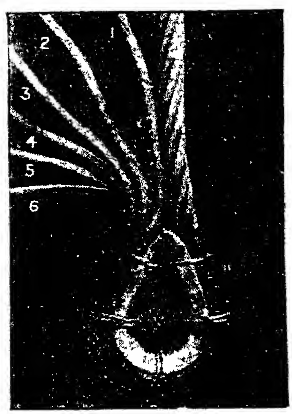


Fig 63.

of the thimble, bend round thimble and tie securely in place with temporary lashing till splice is finished (as in Fig. 62). Open out the strands taking care to keep the loose end of the rope to the left hand (see Fig. 63). Now insert marline-spike, lifting two strands as shown in Fig. 64, and tuck away towards the right hand (that is inserting the strand at the point, and over the spike) strand No. 1, pulling the strand well home. Next insert marline-spike through next strand to the left, only lifting one strand, the point of the spike coming out at the same place as before. Tuck away strand No. 2 as before.

The next tuck is the locking tuck. Insert marline-spike in next strand, and, missing No. 3, tuck away strand No. 4 from the point of

the spike towards the right hand. Now, without taking out the spike, tuck away strand No. 3 behind the spike towards the left hand (as shown in Fig 65). Now insert spike in next strand, and tuck away strand No 5 behind and over the spike. No. 6 likewise. Pull all the loose strands well down.

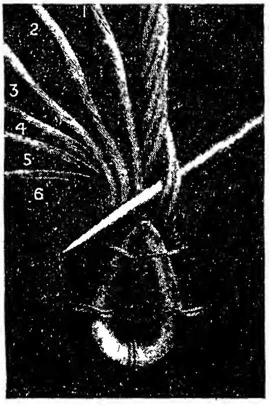


Fig. 64

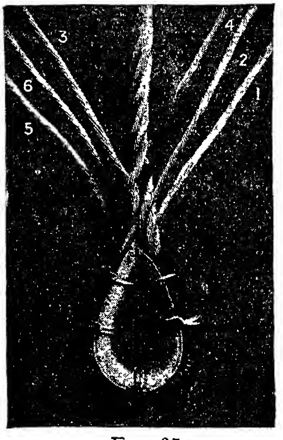


Fig. 65.

Fig. 66.

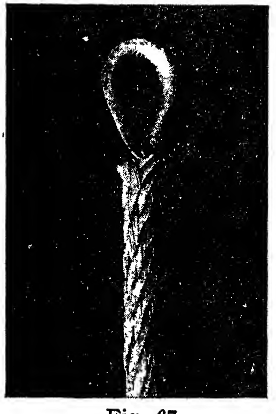


Fig. 67.

This completes the first series of tucks, and the splice will, if made properly, be as Fig. 66 now, starting with strand No. 1 and taking each strand in rotation, tuck away under one strand and over the next strand till all the strands have been tucked four times. If it is intended

to taper the splice, the strands may at this point be split, and half of the wires being tucked away as before, the other half cut close to the splice. Fig 67 shows the finished splice ready for serving over.

It will be noticed that this style of splice possesses a plaited appearance, and the more strain applied to the rope the tighter the splice will grip, and there is no fear of the splice drawing owing to rotation of the rope.

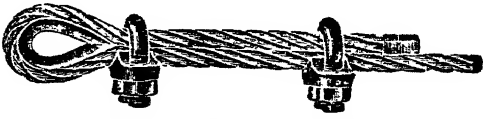


Fig. 68 —Wire Rope Grip.

Fig. 68 illustrates Messrs Davey & Co.'s wire rope grip which offers a quick and effective substitute for splicing and fastening wire ropes by unskilled labour.

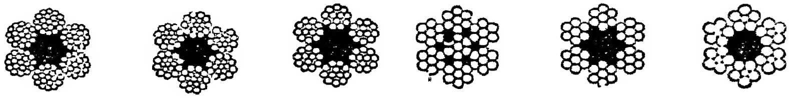


Fig 69 —Sections of Wire Ropes.

Different methods of laying up the wires in each strand and of twisting the strands together are shown in Fig. 69. The black shading represents hearts of hemp rope.

HOW TO MEASURE ROPE.

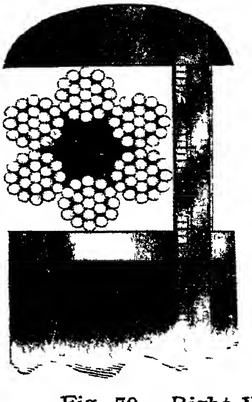
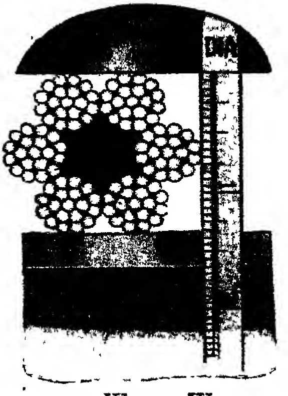


Fig. 70.—Right Way.



Wrong Way.

BLOCKS.

A built block consists of a shell, strop, sheave, pin, shackle or hook

The score of a block is the groove round the outside of the shell (Fig. 71), to take the strop, rope, or wire, when one is to be fitted. The cheeks are kept apart by two pieces of wood, one at the head and one at the tail of the shell to form the "swallow," the name given to the space the rope is rove through.

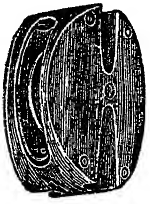


Fig. 71.
A Built Block.

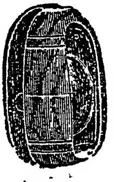


Fig 72.
A Clump Block is cut out of the solid wood.

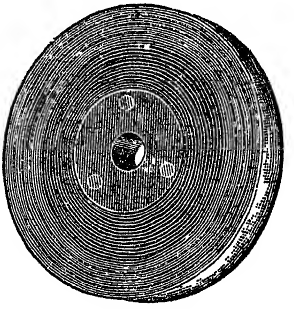


Fig 73.
Sheave Plain Bush

The shells of blocks are usually made of elm or oak as both kinds of wood are good for resisting weather but they must be kept varnished or painted.

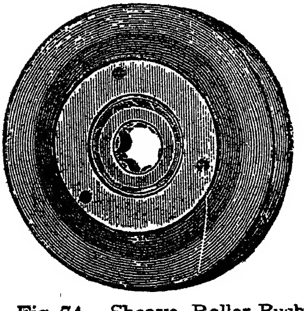


Fig. 74.—Sheave, Roller Bush.

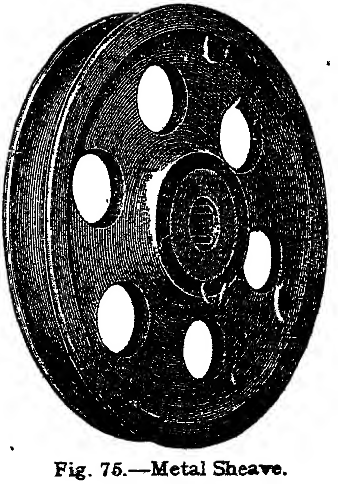


Fig. 75.—Metal Sheave.

The strop may be of rope or wire fitted into the score round the shell and spliced as shown in the illustrations of tackles. The length of a rope strop is about one and one-third the round of the block.

Sheaves are either of lignum vitæ or metal Lignum vitæ is an exceedingly hard wood dark in colour and has self-lubricating properties The bush of the sheave may be plain, that is just a hole drilled in gun-metal (Fig. 73), or a roller bush (Fig 74), which runs with less friction. Metal sheaves (Fig. 75) are used for heavy work. The size of a block is the length of its shell; the size of a sheave is its diameter.

An **External** bound block (Fig 76) is one stropped with a heavy iron band, an eye being welded on it for a hook or shackle.

An **Internal** bound block is one having an iron strop inside the shell, one lug of which is sometimes extended outside the shell in the form of an eye to take the standing part of the purchase The strop can be withdrawn from the shell for cleaning and painting; pins of blocks are scraped and rubbed with blacklead, so also are the sheaves and bush.

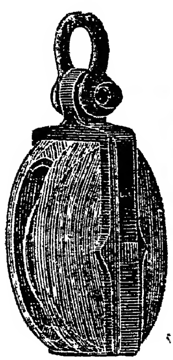


Fig. 76.
External Bound Block

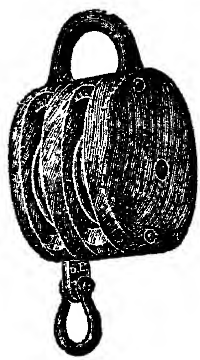


Fig. 77
Internal Bound Block.

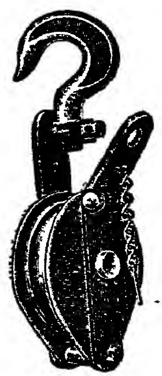


Fig. 78.
Iron Snatch Block.

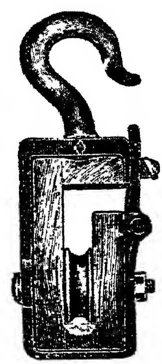


Fig. 79.
Wood Snatch Block.

A **Snatch** block is a loose block having a hinged clamp at the side (Figs. 78 and 79), so that the bight of the rope may be slipped over the sheave and the clamp closed again. They are handy as portable lead blocks. Malleable iron pulley blocks (Fig. 80), are now universally used for cargo work, and Fig. 81 illustrates another of Messrs. Davey & Co.'s cargo blocks fitted with self-lubricating sheaves specially designed for heavy work, the gunmetal centre, or bush, of the sheave having

cavities filled with solidified grease which is only liberated when the sheave is working. *See* grooves in Fig. 75.

The simple machines are the pulley block, the wheel and axle, the lever, the wedge and the screw. All other mechanical appliances are practically a combination of one or more of those simple machines modified in form and application to meet particular requirements.

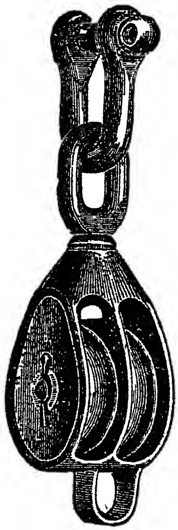


Fig. 80.—Metal Block.

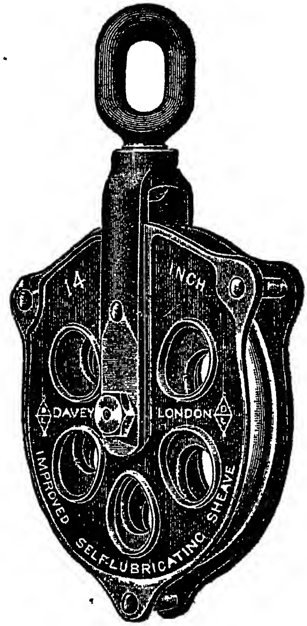


Fig. 81—Cargo Block.

In a simple fixed frictionless pulley (Fig. 82), if W represents a weight of 1 lb. due to the downward force of gravity, and P represents a spring balance held in the hand, the balance will register 1 lb., thus demonstrating that a power or force of 1 lb. has to be exerted to equalise the weight of 1 lb. If the weight of 1 lb. be overcome by exerting more power at P so that W moves slowly upwards, the balance will fully register 1 lb. whilst W moves up the same distance as P moves down. The downward force at C will be 2 lbs. No power is gained by this system and a single pulley is only adopted in practice for convenience generally as a leading block.

Arrange the single pulley so that it is movable as in Fig. 83. Secure

one end of the cord at C and attach the spring balance to the other end at P. Hang a 2 lbs. weight at W. The suspended weight of 2 lbs. is supported half by the cord at C and half by the hand at P as indicated by the balance registering 1 lb. The effort exerted by the hand at P is just

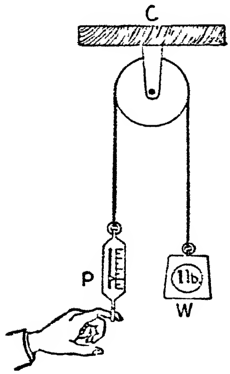


Fig 82.

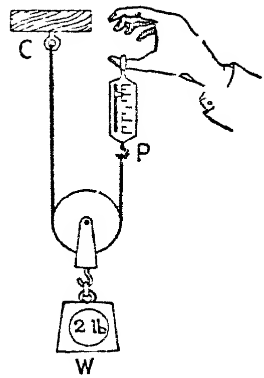


Fig. 83.

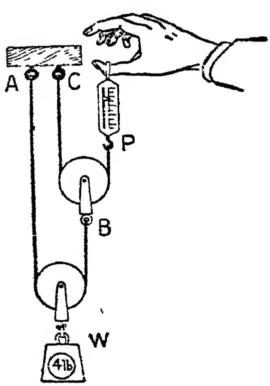


Fig 84.

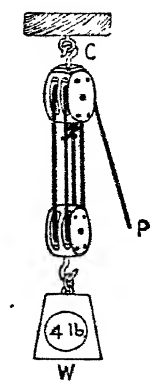


Fig. 85.

Pulley Purchases.

one half of the weight to be supported. The mechanical advantage is said to be 2 because a power of 1 lb. balances a weight of 2 lbs. It will be noted that there are two parts of the cord at the moving pulley and this number gives the mechanical advantage gained by this machine.

If the weight be now overcome by exerting more power at P so

that W moves slowly upwards, the balance will still register 1 lb., neglecting the effect of friction, and the hand will move upwards 2 feet to raise the weight W 1 foot, because the work or power put into the machine at P is equal to the work accomplished by the machine against the resistance of the weight W. This may be expressed in foot-pound units, $P\times 2$ ft.$=W\times 1$ ft or 1 lb $\times 2$ ft $=2$ lbs. $\times$ 1 ft.$=2$ ft.-pds. of work.

The number of pulleys may be increased. Fig. 84 shows two movable pulleys with a 4-lb. weight at W suspended from the lower pulley. The cord AB supports the 4-lb. weight, 2 lbs. at A and 2 lbs. at B attached to the upper pulley. A second cord passed round the upper pulley supports the 2-lb. weight at B, viz., 1 lb. at C and 1 lb. at the hand P holding the spring balance which will register 1 lb., neglecting the weight of the pulleys, thus a power of 1 lb. supports a weight of 4 lbs.; the mechanical advantage of the machine is 4 because by its performance a force of 1 lb equalises a load of 4 lbs.

If the load of 4 lbs. be now overcome by exerting more power at P so that W moves slowly upwards, the hand at P will move 4 feet to raise the load W 1 foot, thus

$P\times 4$ ft.$=W\times 1$ ft. or, 1 lb. $\times 4$ ft.$=4$ lbs. $\times 1$ ft.$=4$ foot-pounds of work, again demonstrating that the work put into the machine at P is equal to the work done by the machine against the resistance at W.

The arrangement as shown in Fig. 84 is not suitable in practice so the sheaves are fitted into blocks as in Fig. 85. The principle is the same, however, and the number of parts of cord at the moving block gives the theoretical advantage or power gained by using the purchase; that is to say, the ratio between the power and the weight which, in this example, is one-quarter without friction.

There are four parts of rope holding the weight and it is evident that the pull on each part will be one-fourth part of the total weight. The load on the hook at C is equal to the weight+tackle+power exerted on the hauling part of the rope. The weight of the load and tackle is constant, but the power will depend upon whether W is at rest or being raised or lowered. When at rest $P=1$ lb., but when in motion the value of P will be increased and diminished according to the speed of raising and lowering. Needless to say, power is gained at the expense of speed. The more sheaves in the purchase the more rope must be hauled through the blocks to raise the weight a given distance, and speed is thus sacrificed to gain power. It is usual in shipwork to allow one-tenth of the weight for every sheave as an additional load due to friction.

PURCHASES:

The **Mechanical Advantage** gained by using a purchase is found by counting the number of parts of rope at the moving block. This, however, is merely the theoretical advantage as friction and the weight of the block and rope are neglected.

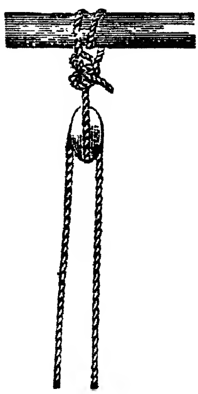


Fig. 86.

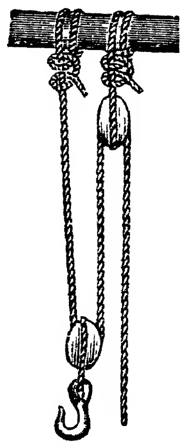


Fig. 87.

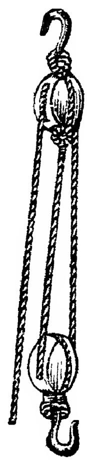


Fig. 88.

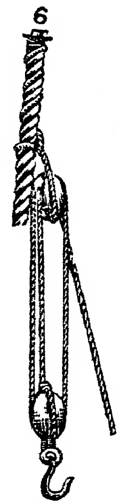


Fig 89

Fig. 90.

Single Whip.—A rope rove through a single block fixed in any position. No power is gained (Fig. 86).

Double Whip.—A rope rove through two single blocks—upper block a tail block, lower one a movable hook block. Power gained—double—that is weight of one unit on the hauling part will balance a weight of two units on the hook block (Fig. 87).

Gun Tackle.—Two single blocks. Power gained two or three according to which is the movable block. If the upper block in the figure is the moving one the purchase is said to be rove to advantage and the power gained is 3; but if the lower block is the moving one the purchase is rove to disadvantage and the power gained is 2 (Fig. 88).

Handy Billy or Jigger.—A small tackle for general use; a double block with a tail and single block with hook (Fig 89).

Watch Tackle or Luff Tackle.—Double hook block and single hook block. If rove to advantage the power gained is 4, but if rove to disadvantage the power gained is only 3 (Fig. 90).

Double Purchase.—Two double blocks. Power gained is 4 or 5 depending on which is the moving block (Fig. 91).

Three-Fold Purchase.—Two three-fold blocks. Power gained—six or seven times (Fig. 92).

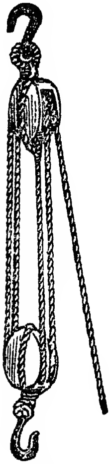


Fig. 91.

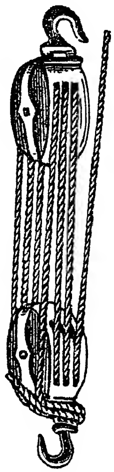


Fig. 92.

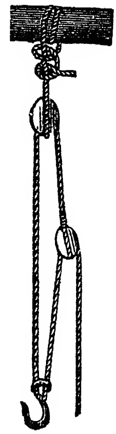


Fig. 93.

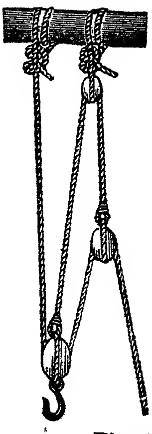


Fig. 94.

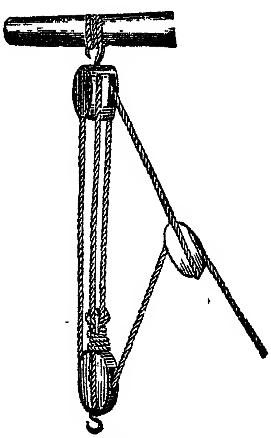


Fig. 95.

A Single Spanish Burton.—Two single blocks and a hook. Power gained—three times (Fig. 93).

A Double Spanish Burton.—There are two forms of this purchase

—Fig 94, by using three single blocks; Fig. 95 by using one double block and two single blocks Power gained—five times The disadvantage of this form of purchase is the very short travel of the lower block as the whip block comes down and meets the lower block going up.

How to reeve a three-fold purchase with the hauling and standing parts of the fall in the middle sheave holes

Place the two blocks on deck with the tails of the blocks towards each other. The one to take the hauling and standing parts of the fall should have a good becket or eye in the tail, and should be laid on its edge having the swallows up and down. (Call this No. 1 block) The other one should be laid on its cheek having the swallows parallel to the deck. Lay the blocks close together and stand in line with them, having No. 1 furthest away from you

Take the end of the fall from the coil and reeve it downwards through the middle sheavehole of No 1 block, then from right to left through the lower sheavehole of the other block, then upwards through the left hand sheavehole of No 1 block, and from left to right through the top sheavehole in the other block.

You should not go wrong now as there is only one vacant sheavehole in No 1 block (the right hand one). Reeve downwards through this, then from right to left through the middle sheavehole in the other block, making the end fast to the tail of No. 1 block.

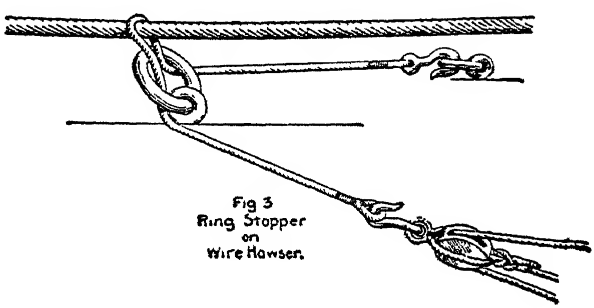
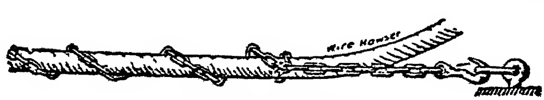


Fig 3
Ring Stopper
on
Wire Hawser.



CHAIN STOPPER ON WIRE HAWSER

CHAPTER III.

STRENGTH OF ROPE.

THE term stress denotes the load put on material, and strain is the molecular disturbance made evident by a change of shape or a fracture of the material due to the stress which has been applied.

Stress comes before strain and the transition from stress to strain introduces another factor called the "modulus of elasticity," Young's modulus=stress divided by strain, within the limits of proportionality.

The term **breaking** or **ultimate strength** is the load or weight applied to material when testing it to destruction.

Rope is made of hemp, manila and coir, their relative strengths being in the order named. Splicing a rope reduces its strength about one-quarter, and three stranded ropes are stronger than the corresponding size of four stranded ropes.

No rigorous rule can be laid down to arrive at the **ultimate breaking strengths** of different sized ropes as so much depends upon the quality of the natural fibre and the process adopted in its manufacture. The **size** of a rope is expressed in terms of its circumference given in inches, and a fair estimate of the breaking strength of good, honest hemp or manila is obtained from the formula $\frac{C^2}{3}$, where C is the size of the rope.

Nor can a hard and fast rule be laid down to estimate the **safe working load** for a given size of rope, but one-sixth of its ultimate strength offers a good factor of safety in order to resist excessive stresses due to sudden jerks on the fall. When an occasional lift is made there is not so much wear and tear on the gear and $\frac{C^2}{7}$ may be accepted as giving a safe margin.

Example.—Given a 3-inch manila rope, estimate its ultimate strength and safe working loads.

$$\text{Ultimate strength} = \frac{C^2}{3} = \frac{9}{3} = 3 \text{ tons.}$$

$$\text{Working load} = \frac{C^2}{7} = \frac{9}{7} = 1\tfrac{2}{7} \text{ tons for occasional lifts.}$$

$$\text{Working load} = \frac{C^2}{3} \times \frac{1}{6} = \frac{9}{18} = \tfrac{1}{2} \text{ ton for continuous working.}$$

Exercise.—Find the breaking strength and the safe working loads for occasional lifts and for continuous working of (*a*) 4-inch, (*b*) $4\frac{1}{2}$-inch, (*c*) 5-inch manila rope.

Ans.	Breaking Strength	Working load Occasional	Working load Continuous
(*a*)	$5\frac{1}{3}$ tons	$2\frac{2}{7}$ tons	$\frac{8}{9}$ tons
(*b*)	$6\frac{3}{4}$,,	2·9 ,,	$1\frac{1}{8}$,,
(*c*)	$8\frac{1}{3}$,,	$3\frac{4}{7}$,,	$1\frac{7}{18}$,,

It may be required to find the size of manila rope suitable for a given load and we then transpose the formula, for if the

working load $= \frac{C^2}{7}$, then C^2=seven times the load and $C = \sqrt{7 \times \text{load}}$.

Example.—Find the size of the smallest manila rope suitable for loads of (*a*) 3 tons and (*b*) $1\frac{1}{2}$ tons.

(*a*) Size of rope $C = \sqrt{7 \times \text{load}} = \sqrt{7 \times 3} = \sqrt{21} = 4{\cdot}6$ inch.

Ans. For a 3-ton load use $4\frac{1}{2}$-inch rope.

(*b*) Size of rope $C = \sqrt{7 \times \text{load}} = \sqrt{7 \times 1{\cdot}5} = \sqrt{10{\cdot}5} = 3\frac{1}{4}$ inch.

Ans. For a $1\frac{1}{2}$-ton load use $3\frac{1}{4}$-inch rope.

To find the number of parts of smaller rope that are equal in strength to one part of a larger rope we simply divide the ultimate strength of the larger rope into the ultimate strength of the smaller one.

Example.—How many parts of a 2-inch rope are equal in strength to a 5-inch rope?

If big C be the size of the bigger rope its ultimate strength will be $\frac{C^2}{3}$, and if small c be the size of the smaller rope its ultimate strength will be $\frac{c^2}{3}$.

$$\therefore \text{number of parts} = \frac{\text{ultimate strength}}{\text{ultimate strength}} = \frac{C^2}{3} \times \frac{3}{c^2} = \frac{C^2}{c^2} = \frac{5^2}{2^2} = 6\tfrac{1}{4}$$

therefore, $6\frac{1}{4}$ parts of 2-inch rope is equivalent in strength to one part of 5-inch rope.

HOW TO HANDLE WIRE ROPE.

When uncoiling wire rope it is important that no kinks are allowed to form, as once a kink is made no amount of strain can take it out, and the rope is unsafe to work. If possible a turn-table should be employed (an old cart wheel mounted on a spindle makes an excellent one); the rope will then lead off perfectly straight without kinks.

If a turn-table is not available the rope may be rolled along the ground.

In no case must the rope be laid on the ground and the end taken over or kinks will result, and the rope will be completely spoiled.

The life of wire rope depends principally upon the diameter of drums, sheaves, and pulleys; and too much importance cannot be given to the size of the latter. Wherever possible the size of the pulleys should be not less than 700 times the diameter of the largest wire in the rope, and never less than 300 times. The diameters of drums, sheaves and pulleys should increase with the working load when the factor of safety is less than 5 to 1.

The load should not be lifted with a jerk, as the strain may equal three or four times the proper load, and a sound rope may easily be broken.

Examine ropes frequently. A new rope is cheaper than the risk of killing or maiming employees.

One-sixth of the ultimate strength of the rope should be considered a fair working load.

To increase the amount of work done, it is better to increase the working load than the speed of the rope. Experience has shown that the wear of the rope increases with the speed.

Wire rope should be greased when running or idle. Rust destroys as effectively as hard work.

Great care should be taken that the grooves of drums and sheaves are perfectly smooth, ample in diameter, and conform to the surface of the rope. They should also be in perfect line with the rope, so that the latter may not chafe on the sides of the grooves.

Wire is manufactured in various grades to suit different requirements, the breaking strengths being given in tables issued by the makers; a safe working load is about **one-sixth** of its ultimate strength.

A table issued by Messrs. Bullivant & Co. is given on page 37 but, when tables are not available, an estimated breaking stress for the flexible steel wire rope generally used for cargo work is given by $2C^2$,

Flexible Steel Wire Ropes (Galvanised)

Flexible Steel Wire Rope. 6 Strands, each 12 Wires				Extra Flexible Steel Wire Rope 6 Strands, each 24 Wires		Special Extra Flexible Steel Wire Rope			
						6 Strands, each 37 Wires		Special Make	
Size Circumference.	Weight per Fathom Approx	Breaking Stress	Diameter of Barrel or Sheave round which it may be worked at slow speed	Weight per Fathom Approx	Breaking Stress	Weight per Fathom Approx	Breaking Stress.	Breaking Stress	Size Circumference
Inches.	Lbs.	Tons	Inches	Lbs	Tons	Lbs.	Tons	Tons	Inches
1	63	1 75	6	·88	2 95	1 0	—	—	1
1¼	1 06	2 5	7½	1 31	4 45	1 56	—	—	1¼
1½	1 44	4 0	9	1 88	6·7	2 0	7 25	—	1½
1¾	2·0	5·5	10½	2 5	8·75	2 88	10 0	—	1¾
2	2 44	7 0	12	3·5	11 85	4 0	13 0	—	2
2¼	3 37	9 0	13½	4 5	14 6	4 88	15 75	—	2¼
2½	4 19	12 0	15	5 44	18 55	5 88	19 75	—	2½
2¾	5 ·25	15 0	16½	6 25	21 95	7 0	24 0	—	2¾
3	6 ·25	18 0	18	7·63	25·7	8 25	29 0	—	3
3¼	7 06	22·0	19½	9·37	30 8	10 38	33 5	—	3¼
3½	8 25	26 0	21	10·75	35·2	11 5	38 5	—	3½
3¾	9 87	29 0	22½	12·19	41 1	13·38	44 5	—	3¾
4	11·25	33 0	24	13 62	46·3	15 ·25	51·0	—	4
4¼	12 ·35	36 0	25½	15·69	52·9	17 12	58 0	—	4¼
4½	13 44	39 0	27	17 75	58 6	19 0	63 5	—	4½
4¾	—	—	—	19 88	66·4	21·69	71 ·25	—	4¾
5	—	—	—	22 5	74 2	24 38	79 25	—	5
5¼	—	—	—	23 25	82·88	27 69	87·75	—	5¼
5½	—	—	—	24·5	91 55	31·0	96·75	—	5½
5¾	—	—	—	—	—	33 75	103·75	—	5¾
6	—	—	—	—	—	36 5	113·75	—	6
6½	—	—	—	—	—	42 5	132 0	—	6½
7	—	—	—	—	—	48 5	154·0	—	7
7½	—	—	—	—	—	55 0	178·5	—	7½
8	—	—	—	—	—	63 0	198·0	202	8
9	—	—	—	—	—	79·0	250·0	257	9
10	—	—	—	—	—	98 0	305·0	318	10
11	—	—	—	—	—	120·0	—	381	11
12	—	—	—	—	—	142·0	—	455	12

In these Flexible Wire Rope Tables, which have been prepared by Messrs. Bullivant & Co., Ltd. (who guarantee the above figures as regards new ropes supplied by them), the wire is calculated as taking a breaking stress of 90 tons to the square inch ; ropes made of wire which is calculated above that will take a proportionately higher breaking stress

where C is the size of the wire and this fits in quite well with the ultimate breaking stresses given for rope having 12 wires in each of the six strands as given in Bullivant's table, but $3C^2$ gives a nearer approach to its breaking strength when there are 24 wires per strand and $3\frac{1}{4}C^2$ for the extra special rope with 37 wires per strand as indicated in the table.

Q What would be the breaking stress of 2-inch wire ropes having 12, 24 and 37 wires in each strand?

Ans (12 wires) $2C^2$, $2 \times 2 \times 2 = 8$ tons.
(24 wires) $3C^2$, $2 \times 2 \times 3 = 12$ tons.
(37 wires) $3\frac{1}{4}C^2$, $2 \times 2 \times 3\frac{1}{4} = 13$ tons.

When referring to the breaking strength of wire rope we shall assume the rule $2C^2$.

Example—Find the ultimate breaking strength, also the safe working loads, of (*a*) 3-inch and (*b*) $3\frac{1}{2}$-inch wire ropes.

(*a*) Breaking strength $2C^2 = 2 \times 3 \times 3 = 18$ tons.

Working load $\dfrac{2C^2}{6} = \dfrac{18}{6} = 3$ tons.

(*b*) Breaking strength $2C^2 = 2 \times 3\frac{1}{2} \times 3\frac{1}{2} = 24\frac{1}{2}$ tons.

Working load $\dfrac{2C^2}{6} = \dfrac{49}{12} = 4\frac{1}{12}$ tons.

Example.—Find (*a*) ultimate breaking strengths, also (*b*) the safe working loads of 2-inch, 4-inch, and $4\frac{1}{2}$-inch steel flexible wire rope for continuous working.

Ans. 2-inch wire (*a*) 8 tons, (*b*) $1\frac{1}{3}$ tons.
4-inch wire (*a*) 32 ,, (*b*) $5\frac{1}{3}$,,
$4\frac{1}{2}$-inch wire (*a*) $40\frac{1}{2}$,, (*b*) $6\frac{3}{4}$,,

Chain is made from steel or iron bars, forged or cast, and built up link by link, every part of guaranteed chain being tested as there is always the possibility of a chain having a link improperly welded, burnt or otherwise defective, and this can be detected only by testing.

The breaking strength of close link cargo chain is about twice its proof load and the proof load is from 2 to $2\frac{1}{2}$ times the average working load. The proof load is the stress applied to the chain when testing it in a Proving House. The size of chain is the diameter of the iron bar forming the link.

Breaking strength is about $30D^2$
Proof load about $12D^2$

Safe working load about $\frac{1}{2}\times 12D^2=6D^2$, D being the number of inches in the diameter of the iron forming the common links, quoted in commerce in eighths and sixteenths of an inch.

Example—Required the breaking strength, the proof load and the working load of a $\frac{3}{4}$-inch iron chain.

Breaking strength $30D^2=30\times\frac{3}{4}\times\frac{3}{4}=17$ tons.
Proof load $12D^2=12\times\frac{3}{4}\times\frac{3}{4}=6\frac{3}{4}$ tons
Working load $6D^2=6\times\frac{3}{4}\times\frac{3}{4}=3{\cdot}4$ tons.

Another rule to find the approximate load for iron chain is $\frac{d^2}{10}$ where d is the size of the chain in eighths of an inch.

Thus $\frac{1}{2}$-inch chain is four-eighths and $\frac{d^2}{10}=\frac{4\times 4}{10}=1{\cdot}6$ tons as a safe working load.

To find the smallest size of chain to lift a given load we can apply the same rule, namely, load $=\frac{d^2}{10}$ $\therefore$ $d=\sqrt{10\times\text{load}}$

Example—Required the smallest size of chain for lifting loads of $2\frac{1}{2}$ tons and 5 tons

$d^2=10\times\text{load}=10\times 2{\cdot}5$ tons $=25$ $\quad d=5$-eighths
Use a $\frac{5}{8}$-inch chain for $2\frac{1}{2}$-ton loads.
$d^2=10\times\text{load}=10\times 5$ tons $=50$ $\quad d=7$-eighths.
Use a $\frac{7}{8}$-inch chain for 5-ton loads.

The Frictional Resistance of a purchase increases with the number of sheaves, and an allowance of about **one-tenth** of the weight to be lifted for every sheave in the purchase is usually added to the weight when estimating the additional force that must be exerted to raise the weight. The theoretical advantage is found by counting the parts of the fall at the moving block. When the single block in a luff tackle is the moving one it is said to be rove to disadvantage and the power gained is three, but if the double block is the moving one it is rove to advantage and the power gained is four; that is to say, a pull, or force, of 1 ton should balance a weight of 4 tons. But in a luff tackle rove to advantage there is the weight of the rope and blocks, also the friction of three sheaves to overcome, so $3\times\frac{4}{10}$ tons $={\cdot}1{\cdot}2$ tons for friction and this should be added to the 4-ton weight, making the total load on the purchase about 5·2 tons. The weight, however, will be distributed almost equally amongst the several parts of rope in

the purchase at the moving block. There are four parts in the luff tackle when rove to advantage so $\frac{5 \cdot 2}{4}$ tons gives 1·3 tons as the load on each part of the purchase.

The weight + friction may be expressed as $W + \frac{nW}{10}$ where W is the weight to be lifted and n the number of sheaves, thus in the above example, $W + \frac{nW}{10} = 4 + \frac{3 \times 4}{10} = 5 \cdot 2$ tons.

Example.—A weight of 4 tons is to be lifted with a gun tackle, find approximately the pull on the hauling part if rove to disadvantage.

Ans. There are 2 sheaves and 2 parts of rope (Fig. 1). Total load=weight+friction$=W+\frac{nW}{10}=4+\frac{2\times4}{10}=4 \cdot 8$ tons. Pull on hauling part $= \frac{4 \cdot 8}{2} = 2 \cdot 4$ tons.

"There is less friction with sheaves of larger diameter than of smaller diameter and with thin rope than with thick rope, so the maximum advantage is gained by using large sheaves and strong small sized rope. Fast winding adds to the tension on each part of rope and there is less tension when lowering the weight than when it is merely hanging on the purchase."

Exercises.

1. A weight of 12 tons is being lifted with a three-fold purchase, find the total load and the pull on the hauling part, when (*a*) rove to disadvantage, (*b*) rove to advantage.

Ans 19·2 tons, (*a*) 3·2 tons, (*b*) 2·75 tons.

2. Find the total load on a double purchase and the pull on the hauling part of the fall when rove to advantage and lifting 20 cwt.

Ans. 28 cwt. and 5·6 cwt.

3. A treble purchase rove to advantage, lifting 40 tons. Find the total load and the pull on the hauling part.

Ans. 64 tons and $9\frac{1}{7}$ tons.

4. Lifting a weight of 15 tons with a luff tackle rove to disadvantage, find the total load and the pull on the hauling part.

Ans. 19·5 tons and 6·5 tons.

The illustration of Messrs. Davey & Co. shews the experimental working stresses on the various parts of a tackle with a load of 1 ton. The pull on the hauling part may be found approximately from the

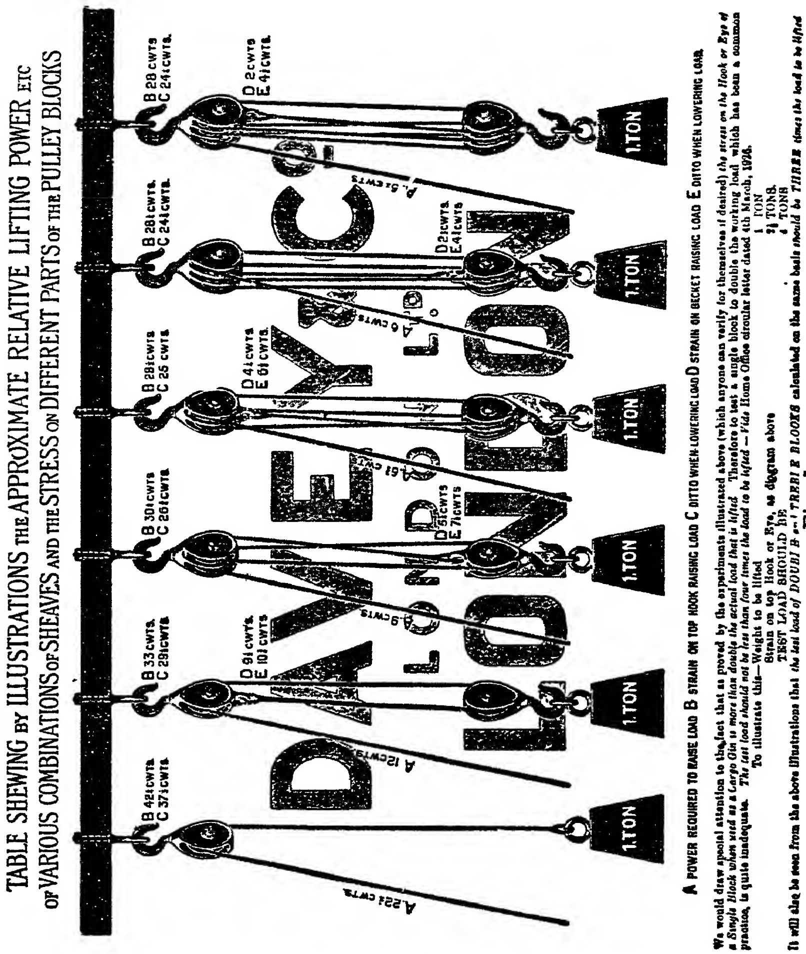


Fig. 1.

general formula, but it is evident that the stress will vary on all parts with the speed of hoisting or lowering. Let us apply the formula and compare our answers with the tested loads given in the illustration.

An approximate connection between the weight being lifted and the stress on the hauling part of a purchase is given by the formula

$$S \times P = W + \frac{nW}{10}$$

where S is the stress or pull on the hauling part
P, the theoretical power of the purchase
W, the weight being lifted
n, the number of sheaves in the purchase
$\frac{nW}{10}$ is the allowance for frictional resistance

The theoretical power or mechanical gain is equal to the number of sheaves when the hauling part of the rope comes off the standing block, but it is increased to the number of sheaves plus 1 when the hauling part comes off the moving block. In the above equation $P=n$, if the purchase is rove to disadvantage, and $P=n+1$ when it is rove to advantage.

Example.—A 12-ton weight is to be lifted with a three-fold purchase rove to advantage; find the tension on the hauling part of the fall and the size of manila rope to use. There is a lead block at the masthead.

S is required. $P=7$, $W=12$ tons, $n=7$ sheaves

$$S \times P = W + \frac{nW}{10}$$

$$S \times 7 = 12 + \frac{7 \times 12}{10} = \frac{120+84}{10} = \frac{204}{10}$$

$$S = \frac{204}{10} \times \frac{1}{7} = 3 \text{ tons, the pull on the hauling part}$$

$$\text{The size of rope } C = \sqrt{7 \times \text{load}}$$
$$= \sqrt{7 \times 3}$$
$$= 4\tfrac{1}{2} \text{ inch}$$

Ans. Tension on hauling part is **3 tons** and use a **$4\frac{1}{2}$-inch** manila rope.

Example.—**The Single Purchase.**—*See* Fig. 1.

A. The pull on hauling part is given as 12 cwt.

$$S \times P = W + \frac{nW}{10} \quad \therefore \; S \times 2 = 20 + \frac{2 \times 20}{10} = 24$$

$S=12$ cwt. which is the same as given.

B. The stress on the top hook when hoisting is given as 33 cwt. It is the load plus the pull on the hauling part plus the weight of the tackle,

that is 20 cwt.+12 cwt.=32 cwt, leaving 1 cwt for the weight of the tackle.

D. The stress on the becket when hoisting is given as $9\frac{1}{4}$ cwt. It is evidently half the load less half the weight of the tackle as the top block is supported by the beam, and half the load is supported by the other part of the fall, that is,

$\frac{1}{2}$ load—$\frac{1}{2}$ weight of tackle

10 cwt —$\frac{1}{2}$ cwt = $9\frac{1}{2}$ cwt. as the stress on the becket, which agrees nearly with the tested stress.

Example.—**The Luff Tackle.**—*See* Fig. 1.

A. The pull on the hauling part is given as 9 cwt

$$S \times P = W + \frac{nW}{10} \quad \therefore S \times 3 = 20 + \frac{3 \times 20}{10} = 26$$

S=8·7 cwt., which is nearly the same

B The stress on the upper hook is given as $30\frac{1}{4}$ cwt. It is the load+the pull on hauling part+the weight of the tackle, that is

20 + 8 7 = 28·7 cwt. leaving 1·6 cwt. as the weight of the tackle.

D. The stress on the becket at the lower block when hoisting is given as $5\frac{1}{4}$ cwt. It is approximately one-third the load as there are three parts of rope supporting the load, less half the weight of the tackle.

$\frac{1}{3}$ load — $\frac{1}{2}$ tackle = stress on becket.

6·7 cwt.— ·8 cwt. = 5·9 cwt. which is slightly over the test stress.

The other tackles may be worked out in a similar way.

Example.—What resistance could be overcome with a three-fold purchase by applying a pull of 2 tons to the hauling part (no lead blocks).

S=2 tons, P=6, n=6 sheaves. W is required

$$S \times P = W + \frac{nW}{10}$$

$$2 \times 6 = W + \frac{6W}{10} = \frac{10W + 6W}{10} = \frac{16W}{10}$$

$$16\ W = 120 \therefore W = \frac{120}{16} = 7\tfrac{1}{2} \text{ tons}$$

The actual weight would be $7\frac{1}{2}$ tons, but the total resistance (weight plus friction) would be greater. Add for friction one-tenth of the weight for each sheave, viz., 7·5 tons $\times \frac{6}{10}$ = 4·5 tons.

Total resistance is 7·5+4·5=12 tons

When a second tackle is hooked on to the hauling part of another tackle the power gained by the combination of the two purchases is approximately equal to the product of their powers.

Example.—A 10-ton load is being lifted with a two-fold purchase rove to disadvantage, (power 4) with a gun tackle rove to advantage, (power 3) secured to its hauling part. Required the stress on the hauling part of the gun tackle

S is required. $P=4\times3=12$. $W=10$ tons. $n=6$ sheaves

$$S\times P=W+\frac{nW}{10}$$

$$S\times12=10+\frac{6\times10}{10}=16$$

$$S=\frac{16}{12}=1\tfrac{1}{3}$$ tons pull on the hauling part of the gun tackle.

Figures 2 and 3 shew a test load of 42 tons on a Mannesmann tube derrick with a five-fold purchase rove to advantage. The fall leads up from the lower block through a lead block at the derrick head, and another at the masthead, and down to a winch. It is required to find a suitable size of wire.

The power gained is 11. There are 12 sheaves, but as the two lead blocks offer a straighter lead for the wire their resistance will be less than the others and they may be taken as one block, so now we have 11 sheaves.

Tension on the hauling part is got from the equation—

$$S\times P=W+\frac{nW}{10}$$

$$S\times11=42+(11\times42\div10)=88{\cdot}2$$

$$S=88{\cdot}2\div11=8 \text{ tons}$$

Special extra flexible steel wire rope is used for heavy lifts the working load of which is about one-third of the breaking strength so

if the working load 8 tons $=\dfrac{2C^2}{3}$

then $2C^2=24$, and $C=\sqrt{12}=3\tfrac{1}{2}$

A $3\tfrac{1}{2}$-inch wire would be suitable. In practice, however, a 3-inch wire would probably be used, as the general formula is not quite so applicable to higher purchases running over sheaves of big diameter. Nor is it desirable, unless for strength and smooth running, to use a

greater power than a four-fold purchase as the extra weight of tackle and frictional resistance neutralise the mechanical advantage of theory.

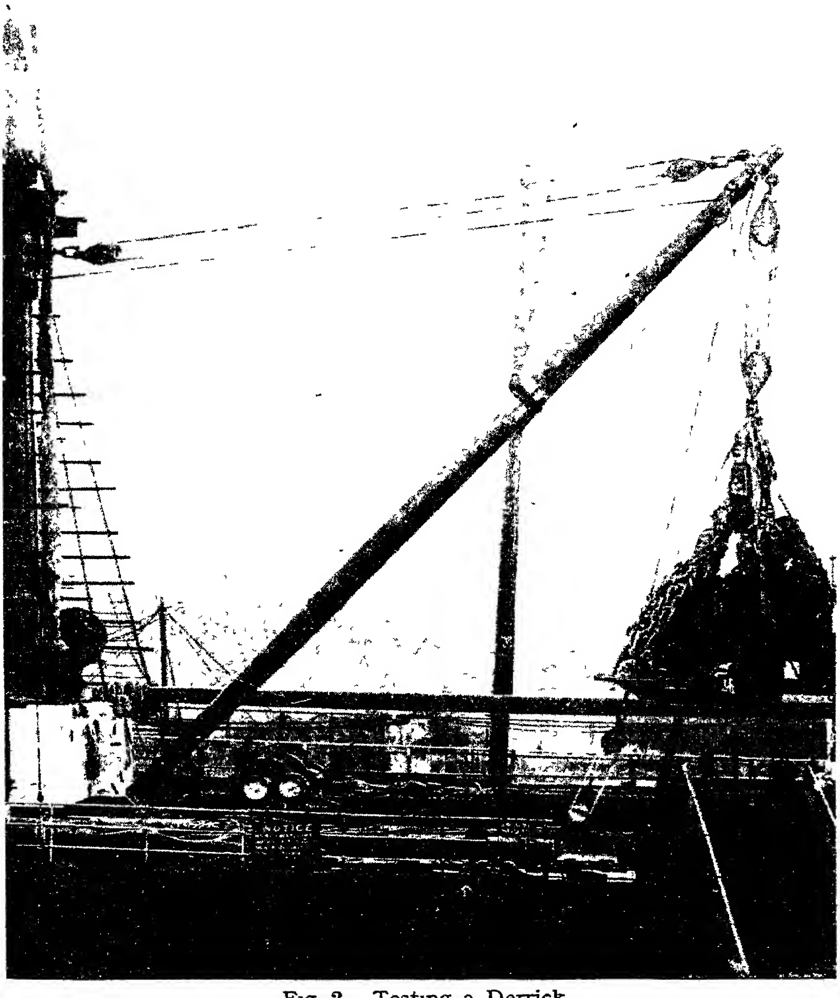


Fig. 2.—Testing a Derrick.

Differential pulley purchases (Fig. 4) are extremely powerful. There is usually one in the engine room travelling on a heavy beam in

the skylight for lifting the cylinder covers and pistons. The upper block has two sheaves rigidly attached to each other but differing slightly in diameter. An endless chain passes over the sheaves the

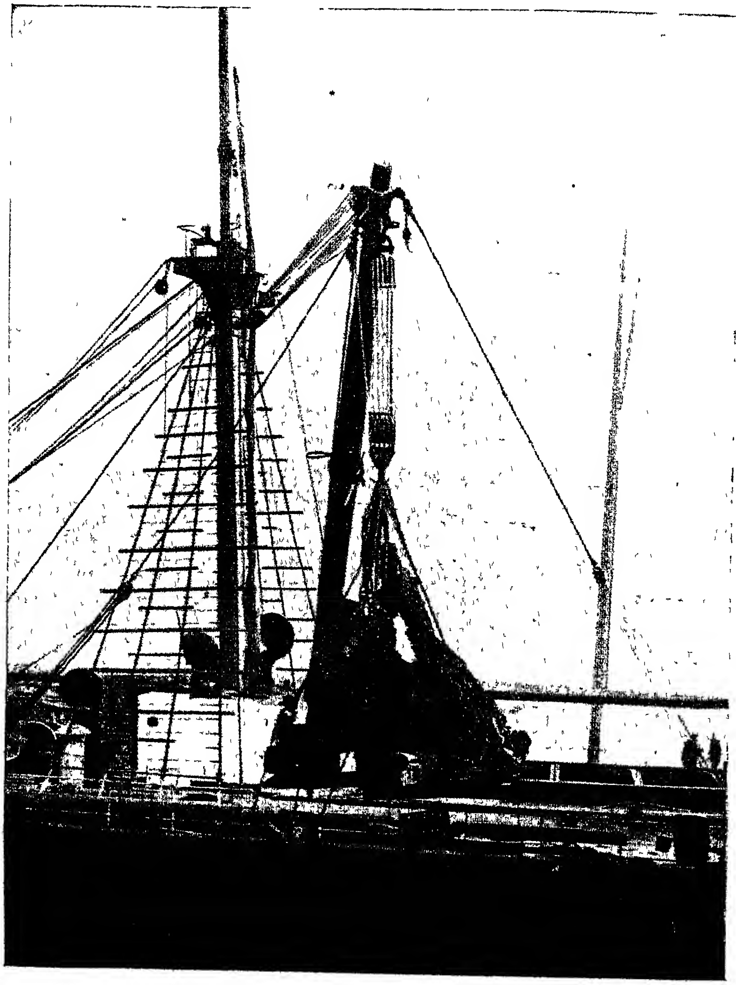


Fig. 3.—Swinging the Derrick.

rims being made with "snugs" to take the links of the chain to prevent it from slipping. The power gained is given by $\frac{2R}{R-r}$, where R is the

radius of the larger sheave and r the radius of the smaller one in the upper block.

Screw chain hoists are sometimes used for lifting heavy weights by hand power (Fig. 5.) The gearing in the system illustrated consists of pulleys of different diameters The hauling or hand chain passing over the flywheel is endless. This flywheel has an axle with a worm screw which engages with the helical teeth of the big wheel. A sprocket

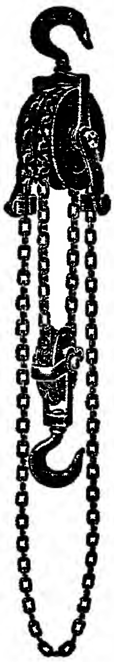


Fig. 4.

Differential Pulley Purchases.

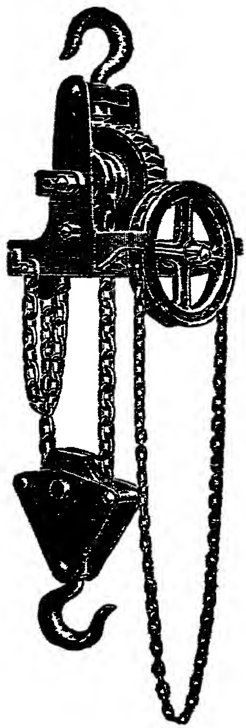


Fig. 5.

is keyed to the axle of the toothed wheel and over this sprocket is seen the stout lifting chain which, in the illustration, is led through a moving, block to increase the purchase, the standing end of the chain being shackled to the framework of the differential gearing.

It works as follows:—The flywheel is turned by the hand chain, which turns the screw axle, which turns the toothed wheel, which turns the sprocketed axle and thus moves the stout lifting chain and raises the weight.

Questions.

1. Name the different fibres used in making rope and that which is most commonly used in merchant ships

2. A new coil of wire is to be uncoiled, how would you go about it?

3. What precautions should be taken with working wire ropes to ensure for them as long life as possible?

4. Write down an equation to express the approximate breaking strength of wire rope.

5. What would you consider a safe working load for a 3-inch wire cargo fall?

6. How is chain measured? Distinguish between the breaking strength, the proof load and the safe working load of chain.

7. What do you understand by a purchase being rove to "advantage" and to "disadvantage"?

8. What is the theoretical power gained by using a gun tackle, a luff tackle and a double purchase? If a load of 2 tons is suspended from each purchase what will be the tension on the hauling part of each?

9. Describe a form of differential pulley purchase.

10. A weight of 30 tons is to be lifted with a three-fold purchase, rove to advantage, with lead block at the derrick end and another at the masthead. Required the tension on the hauling part and a suitable size of steel flexible wire. (Use $\frac{1}{6}$ breaking strength as a safety factor.)

Ans. Tension is $7\frac{1}{2}$ tons. Use a $4\frac{3}{4}$-inch wire.

11. A weight of 25 tons is to be lifted with a two-fold purchase rove to advantage, and a leading block at the derrick end and another at the masthead. Required the size of wire to use.

Ans. Tension on hauling part $7\frac{1}{2}$ tons. Use $4\frac{3}{4}$-inch wire.

12. A weight of 10 tons is to be lifted with a two-fold purchase, rove to disadvantage, and one lead block. Required the size of wire.

Ans. Tension on hauling part $3\frac{3}{4}$ tons Use a $3\frac{1}{2}$-inch wire.

CHAPTER IV.

THE RIGGING OF A STEAMSHIP.

THE figure shows the rigging of a steamship's mast. There are three shrouds on each side of the lower mast fitted with ratlines, and a backstay on each side of the topmast, a topmast stay leading down forward to nearly the stemhead and a forestay, with a staysail on it, set up by means of a bottle screw to a ringbolt on the forecastle deck. This ship has an additional stay from the lowermast-head to the after end of the forecastle to be used as a preventer stay to stiffen the mast when heavy weights are being lifted at No. 2 hatch with the big derrick, which is seen up-ended abaft the mast This stay is disconnected when cargo is being worked at No. 1 hatch.

When only three shrouds are fitted on each side they consist of a single one and a pair. The single one is generally called a "swifter" They go over the masthead in the following order—Starboard swifter, port swifter, starboard pair of shrouds, port pair of shrouds, stay.

When four shrouds are fitted on each side they consist of two pairs. The starboard forward pair goes on first and then a pair on each side alternately. Stay last. All shrouds and the stay are single pieces of wire and are generally shackled on at the masthead. This being the case, it does not matter which is shackled on first. The average size of wire is about 4 inch for the shrouds and a little heavier for the stay. Shrouds are parcelled and served. See page 543.

The Parcelling and Service are always started at the bottom and worked upwards. The parcelling is put on with the lay of the rope, the serving is done against the lay. See page 612.

A Hounds Band is generally riveted round the masthead. This has the proper number of eyes welded on to it to which are shackled the shrouds and stay. Another arrangement for securing the rigging at the lowermast-head is by means of two pieces of angle bar, bent and riveted round the mast a few inches apart. One flange of each is bent to a suitable angle to form two lugs, holes being drilled in these to a proper alignment. The eyes of the shrouds and stay are placed

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between these lugs, each one being secured by a heavy bolt shipped through it. The bolts have a good head and forelock at the lower end to keep them in position.

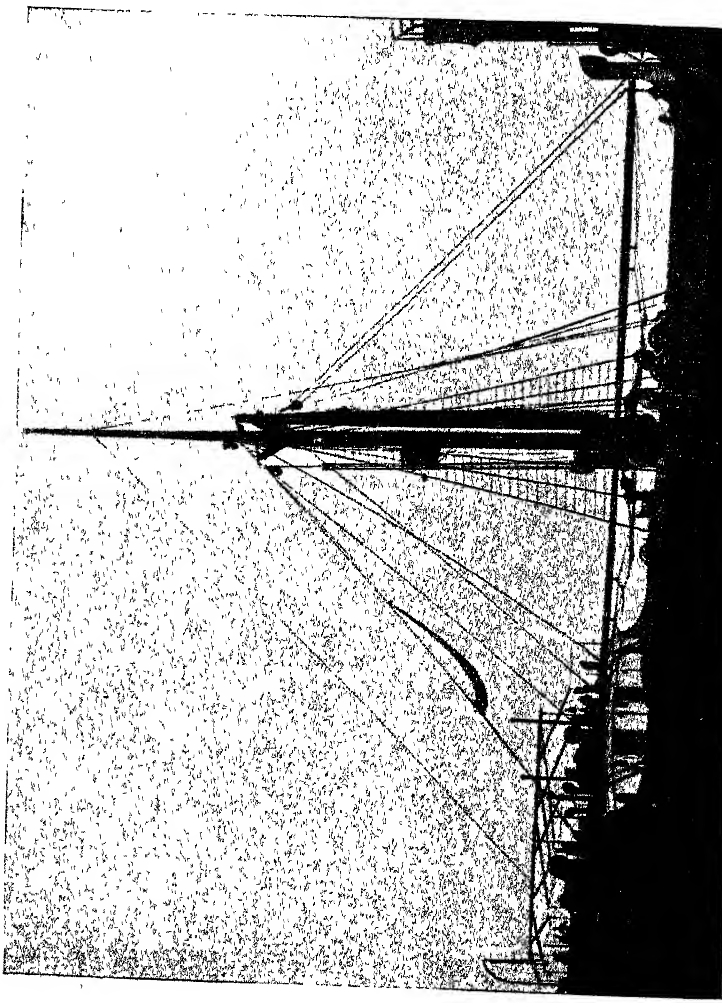

Fig. 1.—The Rigging on a Steamship's Foremast.

When setting up the rigging the stay is set up first and the shrouds afterwards. The forestay is sometimes set up "on its end" to hearts on the forecastle-head deck or on the stemhead. In other ships it is

set up by means of heavy bottle screws to good eyebolts in the same positions

The rigging at the topmast-head is shackled on. An iron hounds band is fitted round the masthead on to which are welded four eyes. One is on the foreside for the stay, two a little abaft the middle part of the mast for the backstays, and one on the after side for the jumper (triatic) stay. This is generally shackled on to one topmast-head, led down through a fitting at the other mast set up with a bottle screw or lanyard.

In old ships a grommet was beaten down on to the hounds of the mast, and large eyes spliced in to the stay and backstays which go on over the masthead. Stay first, then starboard and port backstays.

The weight of the topmast rests on an iron fid, a square bolt which goes through the heel of the topmast, each end resting on the trestle trees. The trestle trees are two short fore-and-aft angle bars riveted to the sides of the lower mast at the level of the fid.

Telescopic Mast.—When a telescopic topmast is first fitted, a short piece of wire or chain is rove through the sheave hole in the heel and made fast at each side of the lower masthead. *To send the mast down.* Take the end of a wire mastrope aloft, marry it on to this short piece, haul it through the sheave hole and make fast to the lowermast-

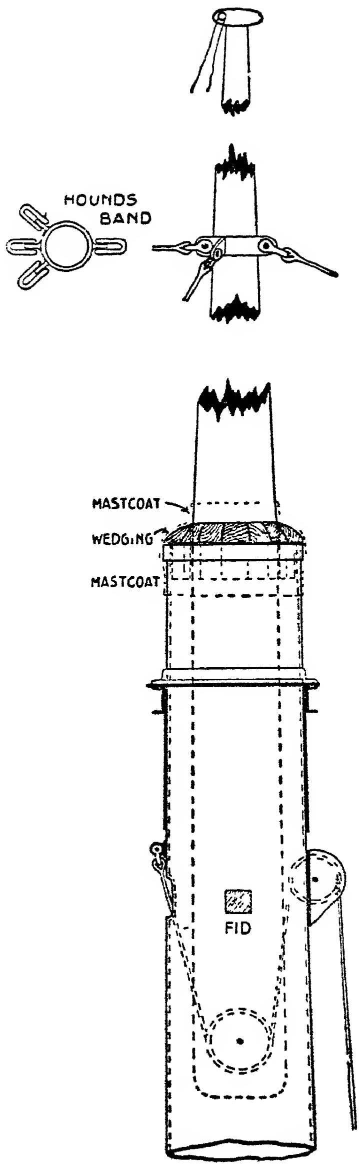

Fig. 2.—A Telescopic Topmast.

head. Many ships are fitted with a permanent sheave between two cheeks at the lower masthead for this rope to reeve over. Should this not be the case a single block must be hung at the masthead and the mastrope rove through it Take the mastcoat off and remove the wedges. Come up the backstays, stay, and jumper stay Lead the mastrope to the winch and take the weight off the fid. Unship the fid. Lower the topmast down inside the lowermast until the hounds band is at the lowermast-head or in the position required. If the backstays and stay are not sent down on deck they can be brought in to the mast and stopped to it out of the way. The jumper stay can be taken adrift if necessary.

Should there be a signal yard or lamp bracket they must be sent down to enable the mast to be lowered sufficiently. Do not unreeve the mastrope.

To send down a Signal Yard.—Hang a good single block at the topmast-head. Take the end of a yardrope aloft, reeve it through this block from aft forward, and make it fast round the quarter of the yard. Take to the winch, heave a very small strain on it and make fast.

Take the yard adrift from its fitting. It does not swing on a truss or parrel in the manner of an ordinary yard. When it comes adrift the yard will cockbill on account of the yardrope being made fast round the quarter. A rope lashing may be useful while doing this part of the job. Lower the yard down on deck.

To send up a Telescopic Topmast.—See that the stay and backstays are shackled on in their proper places and that they are all clear for running when you hoist away. Replace the jumper stay, if it has been taken adrift and reeve off the signal halyards. The mastrope having been left rove when the topmast was sent down, it would be ready for use. Take it to the winch and heave the mast up a bit. Fix the signal yard in position if one is fitted, also the lamp bracket. Unless the signal yard is an unusually heavy one it is not necessary to make another job by sending it up afterwards. Heave away again on the mastrope, and when high enough vast heaving and ship the fid. Ease up the mastrope. Wedge the mast and put on the mastcoat. Cast the end of the mastrope adrift, marry a short piece of wire or chain on to it, haul it through and leave the ends made fast at each side of the masthead so that they are ready for use when required again. Set the stay up, then the backstays and jumper stay.

It may be required at some time to unship a telescopic topmast

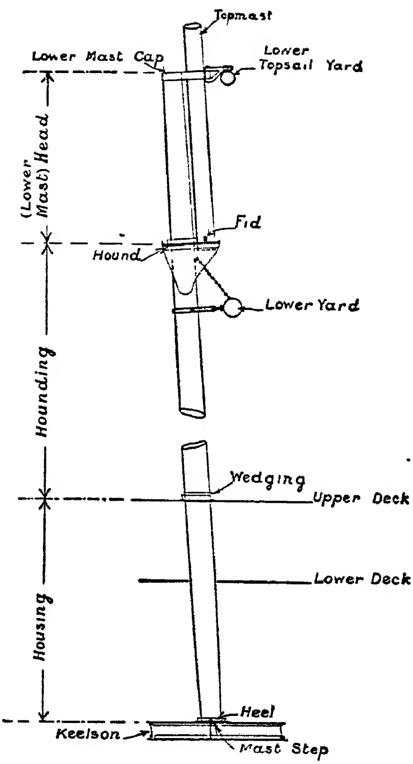

Fig. 3.—Parts of a Lowermast.

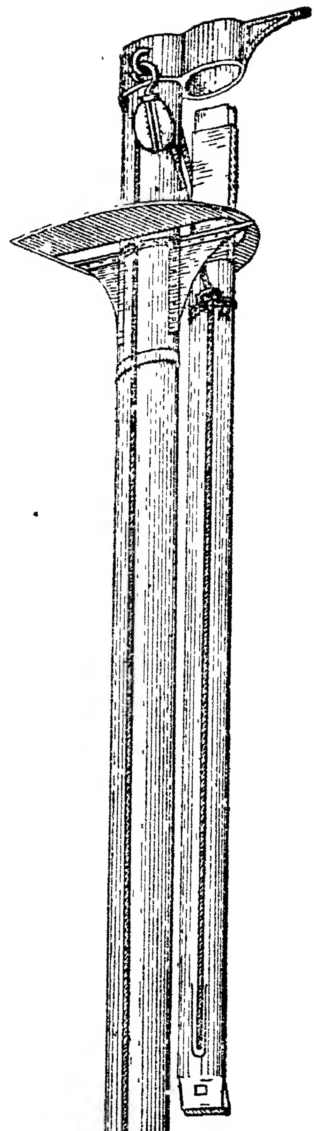

Fig. 4.—Sending up a Topmast. Viewed from the Starboard Side, a little forward of the Mast.

and send it down on deck. The best and quickest way would be to make use of a shore crane. If one is not available then it would be necessary to lash a suitably long spar to the end of a derrick to be long enough to reach well above the lowermast-head. Send down the signal yard, if any, also lamp bracket, etc. Take off the mastcoat and lift out the wooden wedges. Slacken up the rigging screws, unshackle the stays and backstays at the masthead and send them down with a gantline. The end of a wire, rove through a block lashed to the top end of the up-ended derrick, is now lashed to the topmast above its centre of gravity. Lead the wire to a winch and heave away gently, take out the fid, unreeve the "dummy" heel rope, and when the heel is clear of the lowermast-head lower the topmast down on deck.

It would be well to have a slack turn of a preventer lashing round the heel of the topmast and the up-ended spar in case the mast might topple over if the wire has not been lashed high enough up.

The stump of a broken topmast could be lifted out in the same way; some spike nails driven in about the lashing would prevent the gantline from slipping.

Fitted Topmast.—When sending up a fitted topmast lay the mast on deck head forward, after side of mast uppermost. Hang a top block at the lower cap. Reeve the mastrope through this block from aft forward, down between the trestle-trees and through the collar of the lower stay if the stay goes *over* the masthead, and overhaul the end down on deck. Make the wire fast to the topmast-head and lead the hauling part to a winch, heave away and get the topmast up and down on the fore side of the lowermast. Hang off the mast with a lashing, let go the wire and reeve the end through the sheave hole in the heel of the mast, then up between the trestle-trees and collar of the stay and make it fast on the other side of the lower cap. The mastrope is now doubled, heave up and when the topmast-head is entered through the lower cap put the stay and backstays on. If these go *over* the masthead the stay goes on first, then the starboard and port backstays. Heave away again on the mastrope and when high enough put the fid in The ends of the fid rest on the trestle-trees on each side of the mast. Come up the mastrope and unreeve it. Set the gear up, stay first. Send the top block down.

When sending down a fitted topmast hang a top block at the lower cap. Reeve the end of the mastrope through it from aft forward, then through the sheave hole in the heel of the mast and make it fast on the other side of the cap. Come up the backstays and stay, also the jumper

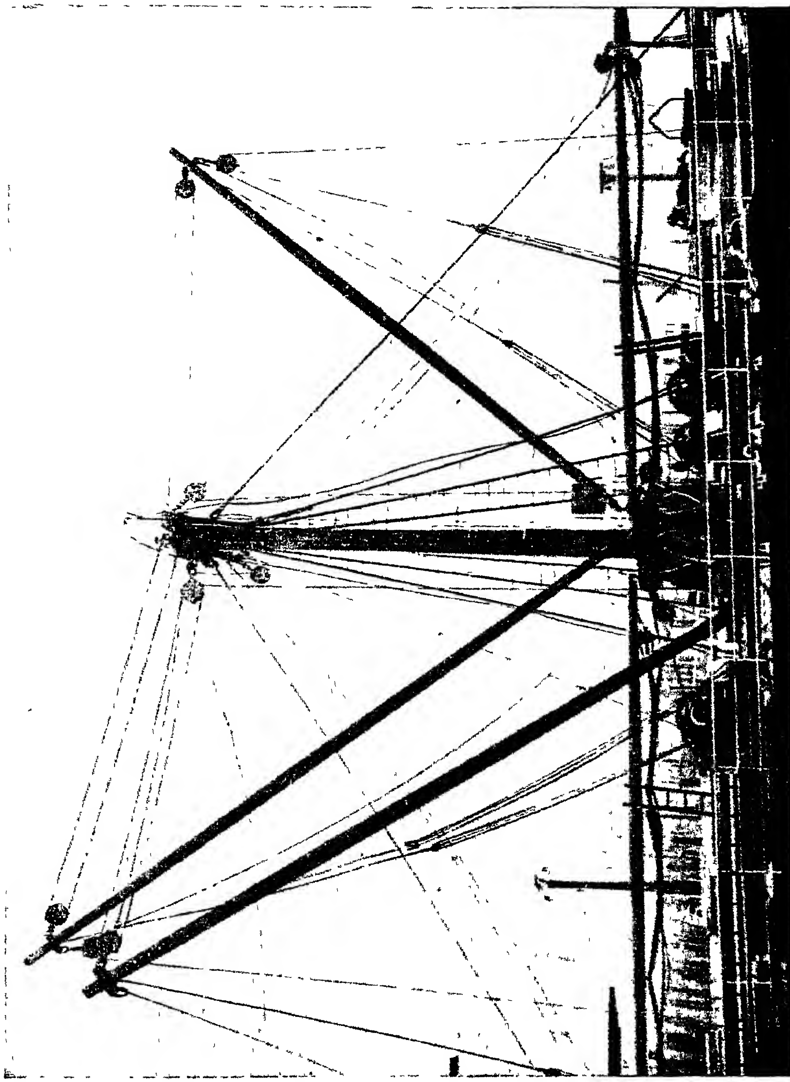

Fig. 5.—Rigging and Derricks. Telescopic Topmast Housed.

stay. Heave away on the mastrope, take the weight off the mast and withdraw the fid. Lower away. When down far enough take off all the gear. This may be stopped at the lowermast-head or sent down

on deck as required. Bend a single gantline to the head of the topmast and lower it down on deck with it. Tidy up the gear.

Derricks.—To rig derricks for discharging overside, keeping one as a standing derrick and the other as a yardarm derrick. Shackle on the guys and cargo gins, reeve off the runners, shackle on the cargo hooks. Top the derricks up into position, one over the hatch and the other guyed out to the side of the ship. If they are fitted with a chain span instead of a topping lift, you will have to rig a tackle from the masthead with which to lift them up. When you have got each one high enough shackle on the chain span, then by easing up the tackle let the span take the weight. See that all the guys are led away clear and set well taut to maintain both derricks in their proper positions.

Figure 5 shows four 5-ton derricks with their heels mounted on a table, and a 20-ton derrick with its heel stepped into a special fitting on the deck. Note the cargo blocks, spans, falls and guys. The telescopic topmast is housed.

Questions

(1) Describe the rigging on a steamship's mast, how it is secured at the masthead and the arrangements made for setting it up tight.

(2) How is any rope parcelled and served and what is the purpose of this dressing on the rope?

(3) Name the parts of a mast.

(4) In what order is the rigging of a mast set up?

(5) Describe how you would house a telescopic topmast.

(6) How would you go about sending down a signal yard?

(7) Send up a telescopic topmast.

(8) Describe how a telescopic topmast could be unshipped.

(9) Take out the stump of a broken telescopic topmast.

(10) You are in a steamer fitted with a fitted topmast, how would you send it down on deck?

(11) Describe the sending up of a fitted topmast.

(12) Describe how you would go about rigging derricks, hoisting them up, and getting as much as possible done to be ready for discharging cargo as soon as the ship is berthed, the ship just entering the port.

(13) The ship has just finished loading, stevedores' gang have left, describe how you would get everything into sea position, decks cleared up ready for getting under way.

STEAMSHIP SAILS

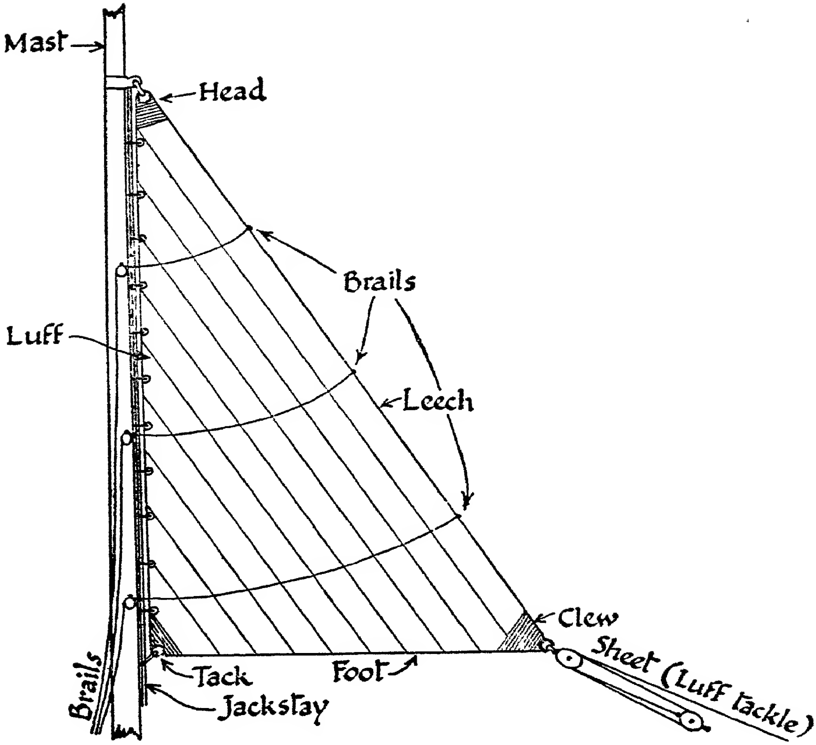

Fig 6.—Steamer's Standing Trysail.

This sail is set on a traveller abaft the mast. The traveller is generally of T section, with iron hanks which can travel up and down on it. Sometimes it is an iron rod held by "dogs."

The head of the sail is shackled to an eyebolt at the masthead. The tack is secured with a shackle or lashing.

The luff of the sail is bent on to the hanks with "robands" often called "rovings" (pieces of spunyarn).

Pieces of 2½ inch manila rope called "brails" are seized at the middle of their lengths on to the after side of the leech. The two ends of each brail are rove through brail blocks shackled to an eyebolt on the mast on each side of the traveller, and led down on deck, forming the hauling parts.

The sheet may be a luff tackle or gun tackle purchase.

To set the sail.—Loose it, let go the brails, haul aft the sheet.

To take it in.—Man the lee brails. One hand take in the slack of the weather ones Ease away the sheet. Brail it close in and make it fast.

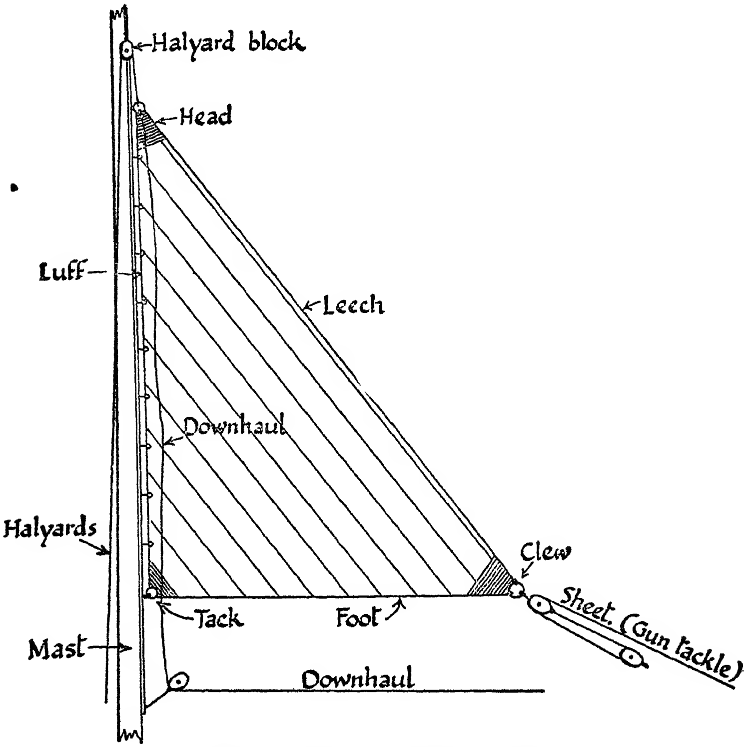

Fig. 7.—Steamer's Hoisting Trysail.

This is another form of trysail often used in steamers.

It runs up and down the traveller instead of having the head secured at the masthead.

It is fitted with halyards for hoisting, and a downhaul for hauling it down, no brails of course being necessary.

In shape it is about the same as the standing trysail shown and explained on the preceding page.

To set it.—Loose the sail, let go the downhaul, and take aft the slack of the sheet. Hoist away, sweat the luff up tight. Trim the sheet.

To take it in.—Man the downhaul, let go the halyards, ease the sheet off and haul the sail snug down. Pass the gaskets.

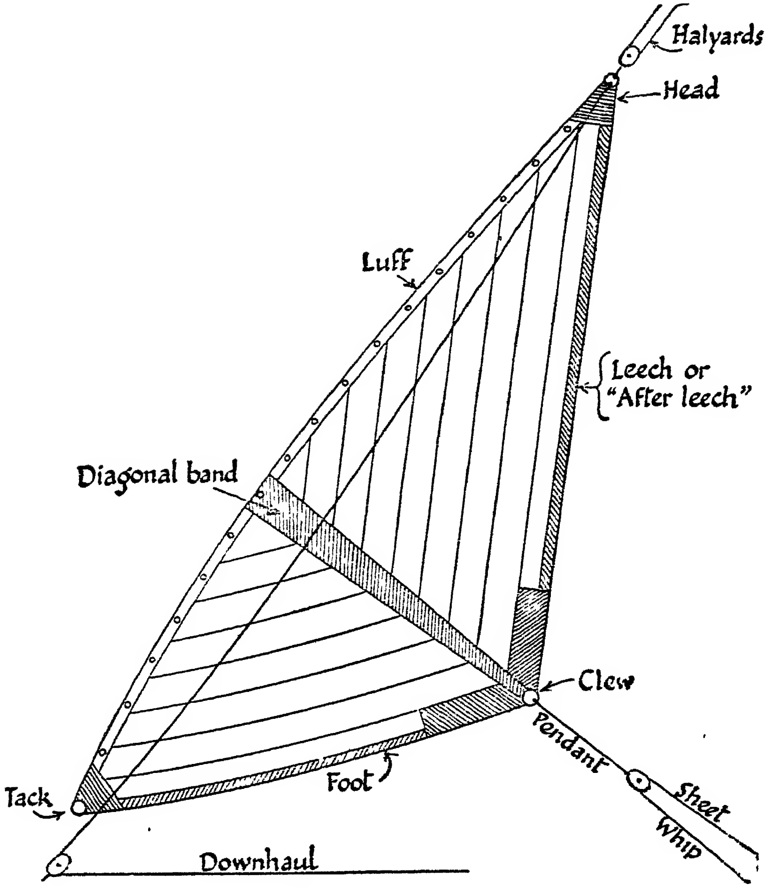

Fig. 8.—Staysail.

The above illustration does not represent a staysail **when it is set on the stay,** but shows the **shape** of the sail together with the names of its different parts and the gear belonging to it.

Note the **round of the luff.** This would not be seen when the sail is set, as the luff rope would conform to the curvature of the stay.

The cloths are parallel to the leech and the foot.

The diagonal band covers the seam joining the two parts, and strengthens the sail against the pull of the sheet. This diagonal method of making a sail is a better one than that of having **all** the cloths parallel to the leech, as the sail is stronger and keeps its shape better.

To set it.—Loose the sail, let go the downhaul and haul the slack o the sheet aft. Man the halyards and "swig" the sail up tight. Trim the sheet.

To take it in.—Man the downhaul, and when all is ready let go the halyards. Haul the sail down, slacking the sheet away as necessary. Let go the sheet and make the sail fast.

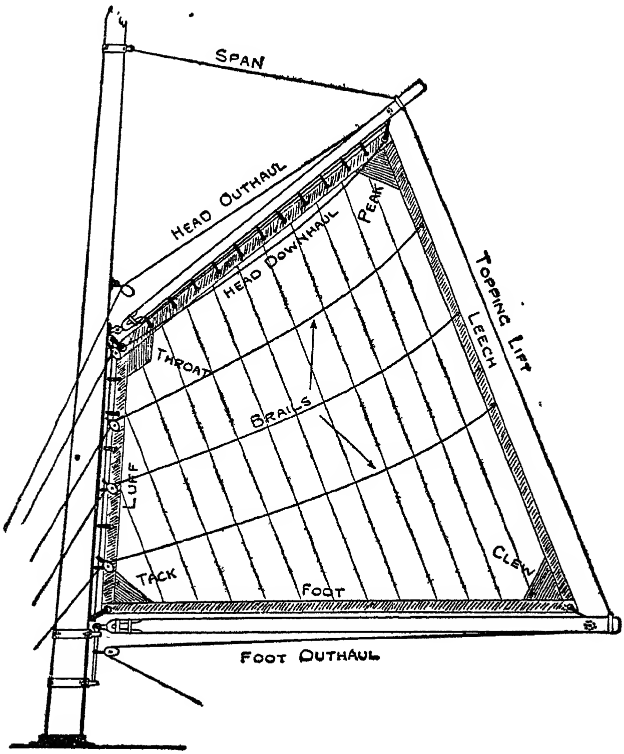

Fig 9.—Spanker.

Figure 9 shows an ordinary spanker as used with a standing gaff and spanker boom.

The luff is bent to a jackstay abaft the mast, and the head to rings on the gaff. The rings are generally made of galvanised iron. There is a good "throat" and "tack" lashing. It is fitted with head outhaul and downhaul, also with a foot outhaul and brails. These brails are fitted as for a steamer's trysail.

To set it.—Hook the foot outhaul on to the clew and haul the slack out, easing off the brails and head downhaul. Pull the head up tight and "swig" the foot out well. Attend to the "vangs" and "boom sheets."

To take it in.—Let go the head outhaul and haul the head snug down first slacking away some of the foot outhaul if necessary. Man the lee brails, slack away the foot outhaul, finally letting go, and brail it close in Pass the gaskets. Haul the gaff and boom amidships.

Note.—Some vessels have a hoisting or "leg of mutton" spanker This is practically the same as a steamer's trysail.

PARTS OF SAILS, ETC.

Define the meaning of the following terms—

Head of a sail.—The **upper corner** of a trysail or staysail. It is fitted with a galvanised iron thimble to take the halyards or head lashing or shackle.

If the trysail sets on a gaff it is that part which is stretched along the gaff that is, **the whole upper edge** of the sail

The head of a **spanker** is the **upper corner** of a "leg of mutton" spanker, but **the whole upper edge** of the sail if it is one which is hauled out along a gaff.

The **whole upper edge of a square sail** is also called the head.

Foot of a sail.—The **lower edge** of **any** sail.

Tack of a sail.—The **lower corner** of a staysail or jib. The lower **forward** corner of a spanker, or of a trysail which sets with its foot in a horizontal direction.

When the yards of a square-rigged vessel are taken well forward, the weather clew of each "course" is bowsed down with a chain or tack tackle. It is then called its "tack."

Clew.—The **after corner** of a fore-and-aft sail, also **both lower corners** of a square sail.

Leech.—The edge at the **sides of a square sail.** All square sails have two leeches.

After leech (also called leech) the edge of a fore-and-aft sail contained between the head and the clew.

In the case of a fore-and-aft sail which sets on a gaff, it is the **after edge** of the sail.

Throat of a sail.—The upper **forward** corner of a spanker or of a trysail which sets on a gaff. It is fitted with a shackle or "throat lashing" to secure it in its proper position.

The upper **forward** corner of a boat's lugsail is also called the "throat."

To set it.—Hook the foot outhaul on to the clew and haul the slack out, easing off the brails and head downhaul. Pull the head up tight and "swig" the foot out well Attend to the "vangs" and "boom sheets."

To take it in.—Let go the head outhaul and haul the head snug down first slacking away some of the foot outhaul if necessary. Man the lee brails, slack away the foot outhaul, finally letting go, and brail it close in Pass the gaskets Haul the gaff and boom amidships.

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Peak of a sail.—The upper **after** corner of a spanker or of a trysail which sets on a gaff. It may be secured in position by a lashing, or hauled out with a "head outhaul."

The upper **after** corner of a boat's lugsail is also called the "peak."

Gaff peak.—The **upper and after end of a gaff.**

Roach of a sail.—Arch or curve in the foot and leeches of square sails.

Round of a sail.—The convex shape given to the luff and foot of a jib or staysail.

Gore cloths.—Cloths cut at an oblique angle to form the "roach" or the "round."

Diagonal band.—A tapered strip of canvas extending diagonally across a fore-and-aft sail from the clew to the luff rope. It covers the seam joining the upper and lower parts of the sail and strengthens it by fortifying it against the pull of the sheet.

Reef band.—The canvas band sewn across a sail in the way of the reef points.

Reef points.—Pieces of point line (good manila) which are fitted in eyelet holes worked through the cloths and reef bands of sails. They are sewn to the **bottom** of the eyelet holes in fore-and-aft sails but to the **top** in square sails. The reason for this is that **fore-and-aft sails are reefed on the foot**, but square sails are reefed on the head.

Linings.—Lengths of canvas worked along the edges of sails before the rope is put on. The outer edge of the lining is secured by the roping of the sail, the inner edge being sewn down with a flat seam. Linings on a steamer's sails are about 1 foot wide except for about 5 feet up from the clew and 3 or 4 feet along the foot where they are generally given a full cloth.

Tabling.—A sail having been cut out and the cloths sewn together, **the edges all round are turned back** for a width of about 4 inches and sewn down flat. That part of the canvas which is turned back is called the "tabling."

CANVAS, ROPE, SAILS, Etc.

Ordinary British sail canvas is made of flax, the best qualities being "all long flax." American canvas is made of cotton.

The threads running lengthwise are called the "warp," and those running crosswise are called the "weft." The finished edge of the canvas is called the "selvedge."

The stoutest canvas is No. 1, the next No. 2, the lightest in general use being No. **6.**

Sail canvas is 2 feet wide, made up in bolts of about 42 yards. The length in each bolt is generally stencilled on the outside to the nearest quarter of a yard. A bolt of No. 1 canvas weighs 48 or 49 lbs.

Tarpaulin canvas is not of such good quality as sail canvas, being generally made of second grade flax. The texture is coarser and rougher, the usual width being 2 ft. 6 ins. or 3 feet

Boltrope is good quality three stranded rope made of the best hemp. It is manufactured from the longest and finest yarns, and tarred with best Stockholm tar and oil. It is laid up much softer than ordinary hemp rope, and is more supple and pliable. It is used for roping sails.

Cable laid rope is a good quality manila or hemp used for trawl warps, and fore and main sheets in sailing vessels. It consists of three ordinary right handed ropes **laid up left handed.** It is therefore **nine stranded.**

A steamer's trysail or staysail is made of heavy canvas No. 1 or 2 for the cloths. The seams are sewn with double seaming twine. Roping twine is used for sewing the boltrope round the edges. The eyelet holes along the luff have a small grummet sewn round them, or are fitted with brass eyelets which are simply stamped in: 2½ or 3-inch boltrope is used for roping the luff and after leech, the foot rope generally being a little smaller. About 4 feet of the rope on the foot and about 5 feet of the leech rope is about an inch larger in size next to the clew, being joined to the smaller rope by means of a sailmaker's splice. Galvanised iron thimbles are worked in at the head and tack, and a heavy galvanised iron ring at the clew.

Flexible steel wire is now superseding boltrope in all kinds of sailmaking.

A steamer's sails, if she has any, are principally for steadying her in a seaway. With a strong beam wind the side pressure on the sails moderates the rolling. They also have some propelling power, and thus help her along. They are very useful in the case of an accident to the engines or propeller.

When bending a standing trysail bring it along to the foot of the mast, and open it out. Fake it down on the deck, having the tack underneath and the head on top. If the brails are not on the sail, middle them and seize them on to the after leech. Eyelet holes are worked in the sail for passing the seizings.

Reeve a gantline through a block at the masthead for hoisting it up. Take the hanks off the traveller abaft the mast and bend one on to each of the eyelet holes in the luff. Hoist away slowly by means of

the gantline, putting each hank back on the traveller as the sail goes up. Shackle the head of the sail on to the eyebolt at the masthead. Reeve the brails through the brail blocks and pass the ends down on deck. Tighten the luff by bowsing down on the tack and securing it.

If the sail is required for immediate use, shackle the sheet on and set the sail by hauling it aft and making it fast If not, haul all the brails tight and pass the gaskets

When bending a hoisting trysail carry it along to the foot of the mast and open it out. Fake it down on deck, having the tack underneath and the head on top.

Take the hanks off the traveller and bend one on to each of the eyelet holes in the luff of the sail, also one on to the head. Shackle the halyards on and make the downhaul fast on to the head cringle. Hoist away slowly with the halyards, putting the hanks back on the traveller as the sail goes up Shackle the tack on to an eyebolt in the mast, also shackle the sheet on to the clew of the sail.

Set the sail by sweating the luff up tight and hauling the sheet aft. If not required at once, haul it down and make it fast.

When bending a staysail open it out at the foot of the stay Take hold of the head, and fake the luff down on the deck, this will leave the tack on top.

Bend a hank on to the tack cringle, one on to each eyelet hole, working upwards, and one on to the head cringle.

Shackle the halyards on to the head cringle, and the tack pendant at the foot of the stay on to the tack cringle. *Bend* the downhaul on to the head cringle by means of a buntline hitch or inside clench. A shackle or clip hooks would cause too much chafe. Shackle the sheet on to the clew.

If the sail is not to be set at once, haul it snug down and make it fast.

Fore-and-aft sails are roped on the port side in order to establish a standard practice, and to enable the head to be distinguished from the tack. Regarding efficiency one side is as good as the other.

When rolling up a fore-and-aft sail for stowing away it is made up on the after leech, which is stretched tight rope to the deck. Carry the tack in and lay it along the after leech, smooth the canvas out evenly, roll the sail up snug. Use manila yarns for stops.

Questions

(1) Describe a steamer's standing trysail, and (*a*) name all the parts, (*b*) how you would set it, (*c*) how you would take it in and furl it.

CHAPTER V.

BOAT SAILING.

The illustration (Fig. 1) shows a life-boat fitted with a "standing lugsail." It is also a free-footed sail (no boom). It differs from the "dipping" lug insomuch that it is not dipped each time the boat is put about, the yard and sail remaining always on one side of the mast; that being the case, they are to windward of the mast when the boat is on one tack, and to leeward when on the other.

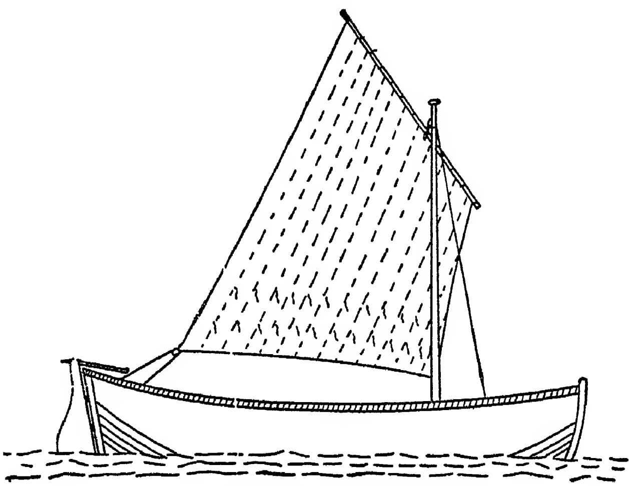


Fig. 1 —Life-boat with Standing Lug.

In the case of a standing lug the tack is secured in a position close to the mast by means of a tack lashing or small tackle. This may lead to an eyebolt in the keelson close to the heel of the mast, or may be secured to the mast itself. In some cases it is hooked to a strop fitted round the mast. The yard is kept close to the mast by the traveller, which is an iron ring round the mast and slides up and down when the yard is hoisted and lowered.

When sailing with the wind well aft, a boom would spread the foot of the sail out and thereby greatly increase its efficiency. This is better than the common practice of holding the clew out with a boat-

hook, which may easily be let go and lost. If a boom is used the foot of the sail may be laced along it, but it is best to have a clew lashing only; there is then a clear space between the boom and the foot of the sail, and any sea or heavy spray that was shipped in the sail in bad weather would immediately clear itself.

Boats of 25 feet or more in length also have a small jib. This is set by means of a halyard and sheet, the tack being secured at the stemhead.

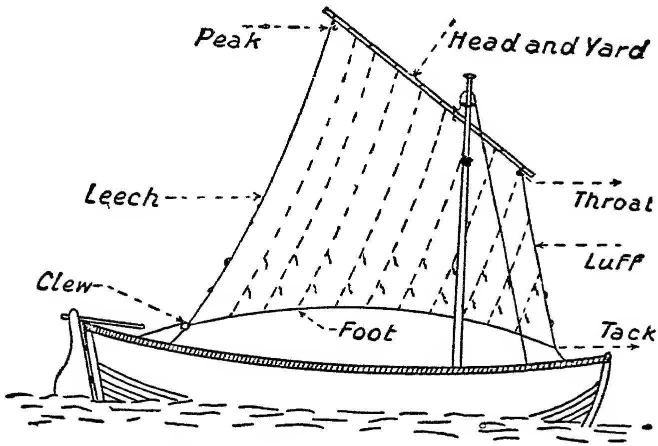


Fig. 2—Life-boat Dipping Lug

The most common form of sail used in ships' life-boats is the "dipping lug," as illustrated in Fig. 2.

It is a free-footed sail, no boom being used. The only gear required for it is the mast, yard (fitted with strop), traveller (with hook) to slide up and down the mast, halyards, tack lashing and sheet. A hook is often used in preference to a lashing for securing the tack in its place.

It is called a "dipping" lug because, when turning to windward, the tack has to be unhooked or got adrift, and together with the fore-end of the yard, dipped round the mast (shifted from one side to the other) every time the boat is put about.

The mast should be stepped in the boat so that the sheave hole is in a fore-and-aft direction. This being done, the halyards will be equally clear at the sheave hole whichever tack the boat is on. If the sheave hole was athwartships, the halyards would be clear on one tack, but would lie across the swallow of the sheave hole on the other tack. The

hauling part of the halyards would also be clear to lead *forward,* thereby making a good forestay for the time being. The mast is generally fitted with a pair of wire shrouds which are set up with lashings at the gunwale.

One or two rows of reef points are usually put in the sail with corresponding reef cringles on the luff-rope for the tack, and on the after leech for the sheet. These, of course, only come into use when the sail is reefed.

SAILING A BOAT

With an Explanation of the Terms in General Use in Sailing Vessels.

When a vessel is sailing close to the wind she is said to be **close-hauled**. If she has the wind abeam or abaft the beam she is said to be "**free**."

It is customary and proper in sailing vessels to steer from the weather side; that is, the helmsman always stands at the weather side of the tiller. A better view of the sails is obtained than is possible from the lee side, and more of the horizon can be seen ahead.

In small vessels, when steering with a tiller, the order "**up helm**" means that the tiller is to be moved towards the wind (to windward), the rudder, of course, canting to leeward, and the vessel's head paying off.

The term "**down helm**" means exactly the opposite to "up helm;" that is, the tiller is to be moved away from the wind (to leeward), the rudder is then canted to windward, and the vessel's head comes up towards the wind.

The order "**steady**" is used in all kinds of vessels, both under sail and steam. It means that the vessel's head is to be kept in that particular direction in which it was at the instant of giving the order.

The helmsman should be told **how much** the course is to be altered so that he may judge how much helm to give her, also when to ease it so that she may not go beyond the desired direction. This also applies when starboarding or porting the helm in a steamer.

When under sail the terms "up helm" and "down helm" are used more than "port" or "starboard."

When the wind is right aft the order "up helm" or "down helm" is understood according to which side of the wheel the man is steering from.

When under examination or practising the Rule of the Road with models it is best to use the terms "port" or "starboard" when the wind is aft.

Some square-rigged vessels will sail as near to the wind as 6 points **from** it, but more often a vessel sailing close-hauled is heading between 6 and 7 points from the direction of the wind. Yachts and other fore-and-aft rigged vessels will sail closer to the wind than 6 points from it, so also will ships' boats when properly trimmed. Many fore-and-aft rigged vessels will sail 4 points from the wind with their sails clean full.

When a vessel is sailing close-hauled she is said to be "**on a wind**" or "**on the wind**" or "**steering by the wind.**" If she falls off through careless steering she is said to be "**off the wind.**"

The term **luff** is used by seamen to indicate the act of bringing a close-hauled ship up in the wind by easing the helm down, and thereby causing the sails to shake. This may be done to ease the pressure on the sails and gear in a squall, or to take the wind out of a sail so that a better pull can be got on a sheet or halyards, or for the purpose of checking a ship's way through the water without quite stopping her.

When the helm is put up again, and her head is canting away from the wind she is said to be "**paying off**" or "**filling,**" and when the sails are quite steady again she is said to be "**full.**"

When a vessel has the wind **free**, and it is required to bring her nearer to the wind, the term "**luff**" is not generally used. The order would be "let her come **up** a point," "let her come **to** a point" or whatever alteration of course was required.

Tacking is to bring the boat's head to wind so as to change from close-hauled on one tack to close-hauled on the other.

Wearing is keeping the boat's head off the wind so as to change from close-hauled on one tack to close-hauled on the other by bringing the wind round the stern.

Gybing is altering course so as to bring the wind round the stern from one quarter to the other.

When sailing a ship's boat with a fair wind, there is nothing to do but steer for your objective and haul in or slacken off the sheet of the sail should the wind alter in direction and always, in an open boat, to be on the alert and ready to slack off the sheet quickly when a gust or squall comes along. The sail is like a bag full of wind. The sheet acts in the same way as a lashing on the mouth of a bag, you must let go the lashing before the bag can be emptied. Similarly, let go the sheet to empty or "spill" the wind out of the sail. It will flap and make a noise because the pressure is off the canvas but the boat will remain upright. The particular danger when sailing an open boat in squally

weather is her lurching and dipping the lee gunwale under water; even if she is well ballasted she may not come upright as the lurching tends to throw the weight of the crew to the lee side and their weight heels her over still further. Never hesitate to slack off the sheet when a puff of wind comes along, it is easily hauled in again.

The science of a boat beating to windward is an application of simple mechanics. A boat with lugsail will make headway when 4 points, 45 degrees, from the wind, and she will zig-zag her way into the wind's eye tack for tack; she will not make good the direction she is heading as ship's boats are flat-bottomed things and make a lot of leeway.

In the figure the arrow and dotted line represent a North wind blowing down the page. *A* is a boat close-hauled on the port tack heading N.E. She tacks at *B* and heads N.W. towards *C* on the starboard tack. She tacks at *C* and heads N.E. for *D* on the port tack. She changes again from port to starboard tack at *D* and heads N.W. for *E*. The distance made good to windward is from *A* to *E*. If *AB* is one mile, *BC* 2 miles, *CD* 2 miles and *DE* 1 mile the boat sails 6 miles in all. It will be found on looking up the Traverse Table with 45° as a course and these distances in the Distance column that the Difference of Latitude column gives 4·2 miles which is the length of *AE*, so that the boat has sailed 6 miles to make good 4·2 miles against the wind. She would actually have to do more as there is always some leeway to make up.

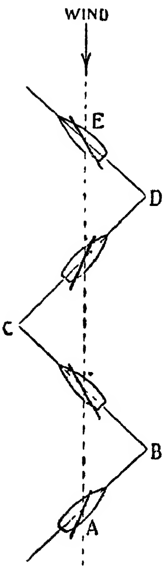


Fig 3.—Tacking to Windward

The trim of a boat is a vital factor in determining her sailing qualities. When a boat is down by the head she will try to bring herself head to wind and when down by the stern she wants to put her stern into the wind. The deep or heavy end of the boat tends to hang to windward; this, of course, may be counteracted with the rudder but the angled rudder would retard the boat's speed. Immediately on getting under way the position of the members of the crew should be changed about until the best sailing balance or trim of the boat is found. The person steering can tell this by the feel of the tiller because when the boat is in nice trim she requires very little helm.

The knack of sailing a boat can only be acquired from experience and no opportunity should be withheld from, or rejected by, responsible members of a ship's crew of getting practice whenever possible.

The crew of the ss *Trevessa* got two hours' notice to prepare for a trip of 1700 miles in open boats when their ship suddenly and mysteriously foundered in the middle of the Indian Ocean in 1923. It was fortunate for the crew that the captain and the chief officer had previous experience in handling a boat under sail.

BOAT SAILS.

1. What materials are boat sails made of?

The cloth should be of best quality duck. The sail should be fitted with reef points sewn into the *bottom* of the holes, reef cringles should also be worked on the luff rope and leech.

The roping should be of good quality manila or boltrope sewn on with roping twine.

Galvanised iron or gunmetal thimbles are used at the throat, peak, tack, and clew, also in the reef cringles.

2. Describe how a boat's sails should be trimmed when she is under way.

When the wind is right aft the sheet should be eased off far enough to allow the sail to be practically at right angles to the keel of the boat.

As the wind hauls out on the side, or as the course is altered *bringing* the wind out on the side, the sheet should be hauled in a little to enable the sail to draw properly and to take full advantage of the breeze then blowing. If the boat carries a jib it should be set, the sheet being eased well off.

As the wind hauls further out on the side, both the main and jib sheets should be taken in a little more, until, when the boat is on the wind (close-hauled), the sheets are flat aft.

As the wind frees again, the sheets must be correspondingly eased off.

Never, under any conditions, should the sheet be made fast in an open boat. It should be taken round a cleat, belaying pin, or thwart, and **held in the hand.**

When the boat is upright, properly ballasted, and the sails well trimmed she should carry the helm nearly amidships, but when she has the wind on the side and is laying over she will require a little weather helm to keep her going straight.

BOAT SAILING

3. **What would you do in a squall** with the wind well free, also when close-hauled?

Having the wind well free, I should put the helm up a little and keep her away *before the squall struck me* I might ease the sheet off as the squall came along, and if it was very stiff lower the yard down. The jib would then keep her going. If no jib, I should leave her a little bit of the lugsail instead.

I should also look out for a possible shift of wind in the squall, and see that I was not *caught by the lee.*

When close-hauled I should mind my helm very carefully, *and luff her through it* easing the sheets off at the same time.

When the squall was over, I should keep her away far enough to fill the sails, and haul the sheets aft again.

If she came up too far when I luffed, or if the wind shifted and I got it on the other side, should shift my sheets across and put her on the other tack, keeping my luff if possible until the squall was over.

"Caught by the lee" means getting the wind on the wrong side of the sail, thereby causing it to come right across to the other side of the boat. This may be caused by a shift of wind as before mentioned, or by careless steering.

"Luff her through it" means keeping her up with the sail shaking in the wind so that the pressure is taken out of it until the squall is over.

4. Does an ordinary ship's life-boat generally do well under sail?

If properly trimmed she should sail fairly well with the wind abaft the beam, but except in smooth water and fine weather would not be much good for getting to windward.

5. What could be done to improve her sailing qualities when **on a** wind?

Fit an iron keel. An iron or steel plate fitted to the wooden keel of the boat for about one-third to one-half of her length amidships and bolted right through would answer the purpose very well.

This should be anything up to 9 inches or 1 foot deep, and tapered with a fair curve at both ends. It should be easily detachable.

Needless to say, a boat so fitted would not be suitable for running up on to a hard beach.

6. How would you set a **dipping lug**?

Lay the yard and sail fore and aft on that side of the mast which

will be the lee side when under way. Hook the tack on in its place, and the hook of the traveller on to the strop on the yard, passing the sheet aft.

Hoist the yard and sweat the luff rope up tight, topping the yard up to the proper angle.

The sheet should be led through a strop placed aft in a suitable position, or round a cleat or belaying pin, or under a thwart, **and held in the hand.**

On no account should it be made fast.

If the boat is going away with the wind well free I should take the tack down (or hook it) on the weather side at a distance abaft the stem which will depend on the size of the boat, the position in which the mast is stepped, and the way in which the boat is going to carry the wind.

If only a hook is fitted in a certain position, of course, there is no alternative but to hook it there.

If going away close-hauled the tack should be secured to the stem head or thereabouts

7. How would you "**go about**" in a boat fitted with a dipping lug?

Keep her clean full for a moment until she gathers good way, and then ease the helm down. When the sail shakes, settle the yard down a bit, unhook the tack, and taking hold of the luff rope with both hands pull down and aft on it, dipping the yard round on to the other side of the mast. Let go the luff rope, hook the tack on again and sweat the luff up tight by means of the halyards. Pass the sheet to leeward, steady the helm.

With a weak or unskilful crew or in bad weather it may be better to **lower the yard right down** when going about instead of only settling it down a few feet. It will take longer, and the boat will lose more way, and go a little to leeward at the same time. It is however safer, and provides less chances for an accident.

To do it this way, ease the helm down and when the sail shakes lower the yard and sail right down on to the thwarts. Unhook the tack, also the strop on the yard from the traveller, and shift the yard and sail across on to the other side of the mast. Hook the tack and traveller on again, hoist away and sweat the luff rope up tight, trim the sheet, mind the helm.

8. How would you set a **standing lug**?

The procedure is the same as for a dipping lug except in the manner

of arranging the tack. This is secured in a position close to the mast instead of being hooked on to the weather bow or stemhead. Secure the tack, hook the strop on the yard on to the traveller, and pass the sheet aft. Sweat up on the halyards until the luff rope is well tight and the yard topped up into the correct position. Hold the sheet in the hand.

If the sail is fitted with a small tack tackle or lashing, it is much better and more seamanlike to hoist the yard up to the required height first and bowse the tack down afterwards.

9. How would you **go about** with a standing lug?

Get good way on the boat, and ease the helm down. As she comes up in the wind the sail will shake, and if there is not too much sea she will come round head to wind and pay off on the other tack. As she falls off, the sheet having been passed to leeward, I should tend it, steady the helm, and shift my position across to the weather side.

When going about under a standing lugsail if the boat is not carrying a jib, the only things to be dealt with are the helm and the sheet.

If a jib is set, the sheet must be eased off at the same time that the helm is put down, and the other one hauled aft as she fills on the other tack.

10. What would you do if, when you put the helm down, she came up into the wind and then stopped, refusing to come right round?

Get an oar out and pull her round. The steering oar would be the handiest, but the bow oar would also answer the purpose. The latter would have to be used on that side which was the lee side before putting the helm down.

If the boat had a jib set, hauling the clew to windward would also help in "boxing her off."

11. Wind aft. How would you **put a reef in** a lugsail?

The method is the same for both "standing" and "dipping" lugs.

Lower the yard and sail right down, reeve the tack and sheet through their proper reef cringles. This will leave the foot of the sail free. Gather it up snugly, and tie the reef points tightly round it. Set the sail again in the same way as if there was no reef in it.

12. **Which rig do you prefer**, the "dipping lug" or the "standing lug?" Give your reason.

For sailing with the **wind aft or well free,** I prefer the dipping lug. The sail spreads better than the standing one by reason of its tack

being taken out to the weather gunwale, and consequently under those conditions it is the more efficient sail of the two. When the wind is aft, the side *opposite* to that on which the sheet is carried may be considered the weather side

For **turning to windward** I prefer the standing lug. It has an advantage over the dipping lug every time the boat goes about as the yard remains at the masthead all the time, no dipping of the yard and sail being required. For this reason, time and leeway are saved specially when beating in narrow waters where frequent tacking is necessary. Under a standing lug a boat should go from one tack to the other without losing her way, and would consequently be more weatherly than if fitted with a dipping lug.

These remarks apply to the conditions under which a ship's boat is likely to be sailed, when she might be manned largely by firemen, cooks, or stewards. *With an expert crew* the difference is not so marked.

13. Are the yard and sail always to leeward of the mast when a boat is under way?

No. With a **standing** lug the yard and sail are to windward of the mast on one tack, and to leeward on the other.

With a dipping lug they are always carried to leeward, being dipped round the mast each time the boat goes about.

14. Are life-boats required to carry a jib in addition to their lugsail?

Life-boats of 25 feet in length or more are required to carry a jib. The carrying of a jib by smaller boats is not compulsory.

15. What use can be made of a jib when the wind is aft, also when "going about"?

When the wind is aft, the clew of the jib may be boomed out on *the opposite side to* the lugsail, thereby giving a larger effective sail area and more way to the boat. It is not necessary in a strong breeze, but makes all the difference when the wind is light.

The jib halyards being well set up, the luff rope makes a good forestay. This may be very useful when the boat is diving into a head sea.

When going about, the jib sheet is eased off at the same instant that the helm is put down. If the boat is "slack in stays" and hangs up in the wind, **hauling the jib sheet to windward** will help her to pay off on the other tack.

16. Describe what is meant by the term "**gybing**," and how it is done ?

When a boat is sailing with the wind a little on the quarter, it may be necessary to put the helm *up* a little and bring the wind *round the stern* on to the other quarter. This manoeuvre is termed "gybing." It should only be done in light winds and fine weather.

With a standing lug, the sheet and clew of the sail are hauled gently and carefully aft as the helm is put up, and are allowed to fall away **on the other side of the boat** as the wind comes round on to the other quarter. The wind will now be on the **other side of the sail.**

A shift of wind round the stern would make it necessary to "gybe;" this shift of wind would always be carefully looked out for.

When sailing with the wind right aft, and by hauling the sheet aft, the wind *is brought on to the other side of the sail*, the sail at the same time going across *to the other side of the boat*, she is said to be **gybed** Note that in this case the boat's course has not been altered.

Do not attempt to gybe if there is much wind or if you have an unskilful crew or a boat-load of passengers. **Lower the sail right down**, and pass it across to the other side of the boat before hoisting it up again.

With a "dipping" lug the yard and sail **must be lowered right down,** and dipped round the mast in all cases. The tack and traveller will have to be unhooked to do this, and, of course, hooked on again before re-hoisting.

17. What particular precautions should be taken when sailing with the wind right aft?

The main thing to guard against **is an "accidental gybe."** This may be caused by allowing the boat to be **caught by the lee** through careless steering or by a sudden shift of wind. Such being the case, the sail will come right across with little warning. With a free-footed sail as used in ships' boats, this may mean nothing more than caps going over the side, but when a **boom** comes across it might be more disastrous. In a strong breeze, the sail or even the mast might be carried away, at the same time the boat is likely to "broach to."

The precautions to take would be to watch the steering very carefully, keep a sharp look-out for any signs of a shift of wind, and take care that she is not "caught by the lee." Should that happen, **ease the sheet right off,** and meet her with the helm to stop her broaching to.

18. Your ship is anchored in an open roadstead where there is no tide. Your port boat is alongside. Describe how you would get her under way and sail into the harbour, the entrance being on your port beam, distant 2 miles.

As there is no tide, both ship and boat will be lying head to wind. Have the yard and sail on the port side of the boat, step the mast and clamp it. Set the sail, when it will simply shake in the wind, the sheet being quite free.

When ready let go the boatrope (should not use the boat's painter as that involves the necessity of hauling it in) and shove her bow off. As she falls off, the sail will fill. Tend the sheet and the helm.

I should keep her heading well to windward of the entrance to allow for leeway. That is, I should go away on the starboard tack sailing her "full and by" when she ought to fetch in.

If on account of leeway, I found that she would not make the entrance on the starboard tack, I should **down sail and mast** and pull for it. It would not be any use going round on to the other tack, as she would continue to make leeway, thereby getting further from her destination. As soon as I saw that she would not fetch in I should not hesitate to get the oars out. The longer I delayed, the further I should have to pull.

19. What would you do when sailing a boat if a man fell overboard?

Throw him a life-buoy or something that will float, taking care not to hit him with it. Down helm and shoot the boat's head up into the wind; lower the sail as quickly as possible, out oars and pull hard towards the man. The boat will be to windward of the man and, when approaching him, have hands leaning over each bow ready to get hold of him. When close to the man I would order "way enough," then "hold water" with the oars so that the boat may not run the man down.

Ships' boats are not built or rigged for handiness in manoeuvring under sail, but should a man fall overboard from a weatherly sailing yacht the quickest way of getting to him is to gybe and then tack towards him.

20. Wind aft, man overboard, what would you do?

I would throw him a life-buoy or any loose article that might support him. Down helm, lower the sail and pull hard towards him. The boat will be only a short distance to leeward of the man and the boat will reach him quicker under oars than by manoeuvring under sail.

21. Would you act differently if you were in a tideway when a man fell overboard?

No. The tide affecting both man and boat in practically the same way, my action would be the same.

22. In what practical way could you help him to get back on board?

A couple of hands could help him in over the gunwale, or over the stern if I was afraid of putting her gunwale under.

A strop made with the end of the sheet or painter, hung over the rudder head or a crutch, could be used as a stirrup. This would be specially useful if I had no crew on board to otherwise help him.

23. The wind blowing right on to the land, how would you get a boat landed on a beach where there is a nasty surf?

I should take precautions to prevent her broaching to as I got into the surf.

If it was a gradually shelving beach there would be more broken water to go through than there would be if it was steeper. Broaching to is caused by a sea catching her aft or on the quarter, or by an oncoming sea lifting the stern and depressing the bow and thus turning her round. I should remember this when deciding where to stow any weighty objects I had on board, distributed amidships would be the best place, also when considering the positions to be taken up by my crew and passengers.

In an ordinary ship's life-boat I should keep good way on her and **run her straight up**, lowering the sail and gathering it in if possible just before she touched. If no signals on shore to guide me I should carefully pick out what appeared to be **the best position** for that purpose. If there was plenty of assistance on the beach she could be quickly hauled up; if not, all hands would have to jump out as soon as she touched and haul her up themselves.

If the boat had a square stern I should turn her round bow on to the sea and **back her in with the oars**, having lowered my sail and unstepped my mast if practicable before getting into the surf. As each sea came on I should give her a little headway against it to prevent her being swung round by it.

A sea anchor, grapnel, or heavy weight could be veered out on the end of a line before approaching the beach. This would act as a drogue, and be of considerable assistance in preventing her getting broadside

on before landing A small anchor let go in a weatherly position would answer the same purpose

Oil distributed from a bag made fast to the sea anchor or to the line being veered out to the ground anchor might be of some service, though nothing will prevent the waves from breaking when water becomes shallow.

24. What signals are used on the home coasts to assist you in choosing a place to land?

A flag held upright overhead, or a white flare held steady or stuck in the ground, indicates a place where I might attempt to land.

A flag or white flare waved from side to side indicates that landing is extremely dangerous.

A flag waved to right or left and then pointed in one direction, or a white flare held steady and carried along shore to right or left, indicate the direction in which the best landing will be found.

25. What precautions would be necessary for safety if you were carrying a boat-load of passengers?

I should be careful to see that the boat was properly trimmed and not overloaded.

Should make a number of my passengers sit or lie down in the bottom of the boat, the remainder sitting on the side benches and thwarts in positions which I should choose for them, having consideration for the working of the sails and manning of the oars if necessary. If the wind was on the side should want more of them to windward than to leeward.

In the event of having to go about should instruct some of them as to moving across to windward at my orders as she came round.

Should see that all had their life-jackets on, and remind them that their safety depended on the prompt obeying of any orders I might issue to them.

Should realise my own responsibility, remembering that should any awkward conditions arise the safety of all would depend on my judgment and action.

26. Where do you make the lugsail halyards fast?

Forward of the mast on the weather side. They will then help to support the mast, acting as stay and shroud.

27. How would you bend a lugsail to the yard?

Pass a good throat and peak lashing, having the head of the sail well stretched along the yard. Pass good stops through each eyelet

hole and make them fast round the yard. Separate stops are preferable to a lacing as if any part of the lacing carried away the whole head of the sail would be adrift except the throat and peak lashings.

28. How much of a life-boat sail is roped?

The head, luff, and round the tack. Also round the clew and up the after leech as far as the reef cringles. The remainder of the foot and after leech are generally strengthened only by the tabling.

29. How would you reef a lugsail when on the wind?

Luff the boat up sufficiently to spill the wind out of the sail. Lower the yard down and gather the sail into the boat. Shift the tack and sheet to the reef cringles. Gather up the slack of the foot neatly and tie the reef points round it. Do not **roll** up the foot as it holds more water when done that way. Hook the tack on to the horse, pass the sheet aft. Hoist the yard up again, tend to the sheet and helm.

30. How would you heave to in a life-boat when running before a strong breeze?

Ease off the sheet a bit to take some of the weight out of the sail. Lower the yard down and gather the sail into the boat. Keep her steady by means of the steering oar. Watch for a smooth, round her to and heave the sea anchor over. Make everything snug in the boat.

SAILING BOAT RULE OF THE ROAD

Preliminary—Risk of Collision.

"Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist."

"Art. 17.—When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, viz.:—

(*a*) A vessel which is running free shall keep out of the way of a vessel which is close-hauled.

(*b*) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(*c*) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(*d*) When both are running free, with the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

(*e*) A vessel which has the wind aft shall keep out of the way of the other vessel.

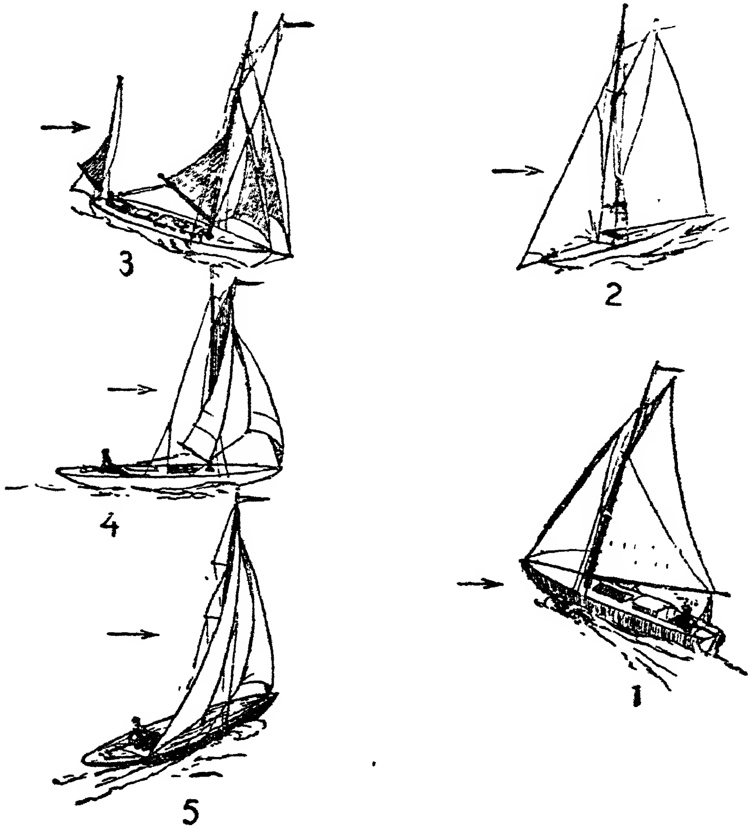


Fig 4.—Rule of the Road.

Suppose you are practising boat sailing in a harbour with several other sailing craft tacking, gybing and manoeuvring about, crossing and re-crossing ahead of each other, and let us imagine ourselves to take a trick at the tiller of each of the five boats in turn as shown in Figure 4. The boats are proceeding in the direction they are heading, the wind is West blowing across the page from left to right as indicated

by the arrows and the pennants at masthead or gaffend. The yachts are sloop rigged (mainsail and one jib), except No. 3, which is a yawl rig as the jigger mast is abaft the tiller; when the jigger mast is forward of the tiller the vessel is ketch rigged.

Boat No. 1 is close-hauled on port tack.
No 2 is close-hauled on starboard tack.
No. 3 is running free with the wind on her starboard quarter
No. 4 has the wind right aft.
No. 5 is running free with the wind on her port quarter.

Refer to the diagram and state what you would do for each of the other four boats in the following cases if meeting them so as to involve risk of collision. Consider one boat at a time and cover with your hand the other three boats.

What would you do if (*a*) in Boat No. 1, (*b*) in No. 2, (*c*) in No. 3, (*d*) in No. 4, (*e*) in No. 5?

(*a*) No. 1 is close-hauled to port. Keep clear of No. 2 as she is close-hauled to starboard. Stand on for Nos. 3, 4 and 5 as they are all running free with the wind well abaft the beam.

(*b*) No. 2 is close-hauled to starboard. Stand on for all four boats. For Nos 3, 4 and 5 because they are free and for No. 1 because she is close hauled to port.

(*c*) No. 3 is free with the wind on starboard quarter. Keep clear of Nos. 1 and 2 because they are close-hauled. Stand on for No. 4 and No. 5. For No. 4 because she has the wind aft and for No. 5 because she is free with the wind on her port quarter.

(*d*) No. 4 has the wind right aft. She keeps clear of all the other boats.

(*e*) Nos. 5 has the wind on the port quarter. Keep clear of No. 1 and 2 because they are close-hauled. Keep clear of No. 3 she is free to starboard. Stand on for No. 4 as she has the wind right aft. If No. 4 had the wind on her port quarter as might be indicated by her main boom being out to starboard I would still stand on as she would then be the weather ship, that is, she has the wind on the same side as me and to windward of me.

CHAPTER VI.

SECTION I.—SHIP'S BOAT.

Boat Lowering

The launching of a boat from a small ship at sea in moderate weather is an easy operation as the crew, being few in number, are usually experienced seamen, well trained and accustomed to team work. North Sea fisherman often remain at sea for a considerable time, and they convey in an open boat in all kinds of weather the boxes of fish to the fast steam carriers who run the fish to market And were it not that this is the ordinary work-a-day business of these hardy and experienced boatmen, the operation in stormy weather would be hailed as a feat of practical seamanship.

In large cargo steamships the launching of a life-boat is a more difficult job owing to the height of the boat deck above the waterline. Cargo ships are equipped with life-boat accommodation under davits on each side of the ship sufficient to carry all hands. Bigger boats are therefore needed and these require heavier davit tackles, the awkwardness of launching the boats being further increased by the inexperience of the crew who are seldom or ever exercised in real boatwork at sea, their only practice being an occasional boat station and the lowering of boats for inspection purposes in harbour.

The problem of carrying a sufficiency of buoyant life-saving appliances in ocean passenger liners to accommodate all hands is complicated, not so much by the large complement of passengers and crew they may carry, but mainly by the difficulty of providing stowage space to provide boats for all and devising mechanical launching arrangements to get the boats lowered down the ship's side, a distance sometimes of 50 to 70 feet, and to get them clear of the ship's side in the event of a sudden emergency call.

Legislation regarding life-boat and buoyancy equipment was introduced after the loss of the *Titanic* in April, 1912. This 52,000-ton liner foundered after collision with an iceberg in mid-Atlantic in calm but hazy weather. The ship was not at first expected to founder and

all her boats were launched leisurely and deliberately, filled with their full complement of people and ordered to stand by around the ship. The ship, however, settled down slowly and eventually sank, $2\frac{1}{2}$ hours after striking the berg, taking with her 1531 souls who stood helpless on deck as there were no more boats or rafts left for them to embark upon. Wireless telegraphy was not then compulsory nor was a continuous wireless watch kept at that time, and the crowning tragedy of the *Titanic* was the presence only 8 or 10 miles away of a wireless equipped ship whose operator was off duty while the S O.S. of the sinking liner was searching the ocean for aid which arrived four hours after she foundered.

Large liners are now equipped with a multiplicity of life-boats and buoyant apparatus having a floatable capacity capable of supporting the total number of persons on their passenger certificate plus 25 per cent.

DAVITS.

The most expert and ingenious of naval architects and engineers have applied their brains to the problem of providing simple and reason-

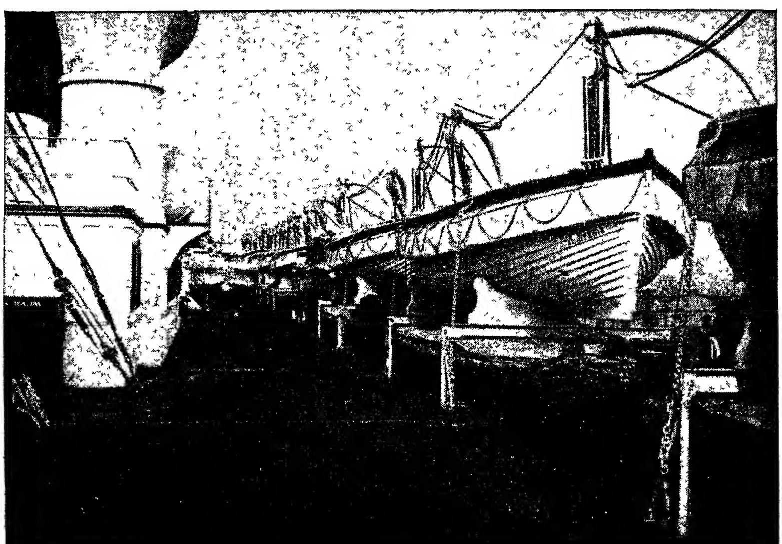


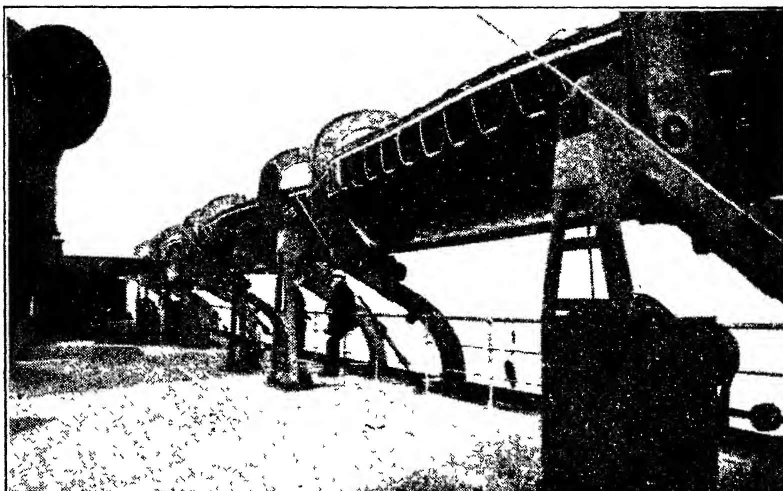
Fig. 1.—Radial Davits, a Liner's Boat Deck.
Note tackle and springs on the funnel guys to allow for expansion.

ably fool-proof launching apparatus of a mechanical type which would be effective in an emergency with the ship in a seaway and listed to a considerable angle.

Modern davits are of three types designed on the radial, the quadrant and the gravity principles, as shown in the various illustrations.

The Two Davit Radial Type is a survival of sailing ship days when only man-power and rope tackles were available at sea. They are still being fitted in steamships, but the system has little to commend it as it is cumbersome, slow and awkward to work, especially when the boats are housed inboard.

The Welin Quadrant Davit is well known, and is specially adapted for handling one boat, or two boats stowed either abreast or over each other, or for nested boats, the davit being designed for the rapid and effective lowering of the life-boats in an emergency by persons who may have had but little practice in the operation.



Control Lever

Fig. 2.—Welin-Maclachan Gravity Davits. Boats in stowed position.

The Welin-Maclachlan Gravity Davit enables one man to lower a life-boat of any size, and fully laden, from its stowed position on the ship down to the water by the simple process of operating a hand lever. The boat is stowed on cradles mounted on rollers which move over parallel trackways laid at right angles to the ship's side and carried down to the embarkation deck. The trackway or launching

skids extending inboard over the deck are given a declivity of 30 degrees, so the boat can be launched against a list up to this angle.

Fig. 3.—Boat at Embarkation Deck.

The falls are of single wire rope led to, and stowed on, a simple hand winch which operates both falls simultaneously.

When launching, the brake lever of the winch is lifted, and the cradles and boat move together under their own weight until the cradles

reach the stoppers. The cradles remain at rest on the stoppers and the boat comes automatically alongside the embarkation deck, irrespective of list. When the life-boat has its full complement on board, the brake lever is again lifted and the boat continues to the water. The hoisting of the boats is effected by means of the winch, and in the case of the larger class of boats electric hoisting power winches are supplied for lifting the boats up the ship's side to the stowed position In tests carried out under inspection of Board of Trade officers, the time occupied from the releasing of the gripes until the boats reached the water (a distance of 40 feet) varied between 20 and 28 seconds, the whole operation being carried out by one man.

1. You are in charge of a boat's crew of 10 men undergoing a Board of Trade examination for a certificate as lifeboatman; how would you place them, and what orders in succession would you give to carry out the operation of swinging out the boat, lowering it, and getting away clear of the ship's side, with radial davits?

Hang the side ladder over at the boat station.

Crew line up and number off from forward, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

Nos. 1 and 10 into the boat. No. 1 pass out the forward fall and see life-lines clear. No. 10 pass out the after fall and see the bottom plug is in. Nos. 2 and 3 pass the end of the slip painter into the boat.

Nos. 4 and 5 attend to the forward fall.

Nos. 6 and 7 let go the gripes.

Nos. 8 and 9 attend to the after fall.

Nos. 2, 3, 4 and 5 tail on to the forward fall.

Nos. 6, 7, 8 and 9 tail on to the after fall.

Take the weight of the boat and down chocks Nos. 2 and 3 to the forward guy and Nos. 6 and 7 to the after guy.

Slack away guys and swing the boat out, then steady tight the guys and lower the boat to the rail. No. 10 ship the rudder. Crew into the boat, leaving Nos. 4 and 5, 8 and 9 at their falls. Lower away. Fend the boat off from the ship's side as she goes down. When the boat touches the water, let go both falls together. Nos. 4, 5, 8 and 9 slide down the falls, or the life-lines, or go down the ladder into the boat. Follow them myself.

When the crew are in their places in the boat give the order "Crew—ship rowlocks and oars ready." No. 1 slip the painter and push off forward with the boathook. No. 10 at the tiller. "Crew—out oars." Push off from the ship's side. Give way.

2. How would you launch a life-boat with the Welin Quadrant Davit fitted with tackle falls and given 6 hands?

Number off the crew 1, 2, 3, 4, 5, 6.

Nos. 1 and 2 into the boat, pass out the davit falls, bottom plug in and see life-lines clear.

No. 3 pass the end of the slip painter into the boat. No. 4 let go gripes and down chocks, then Nos. 3 and 4 man the turning gear at each davit and turn the boat out.

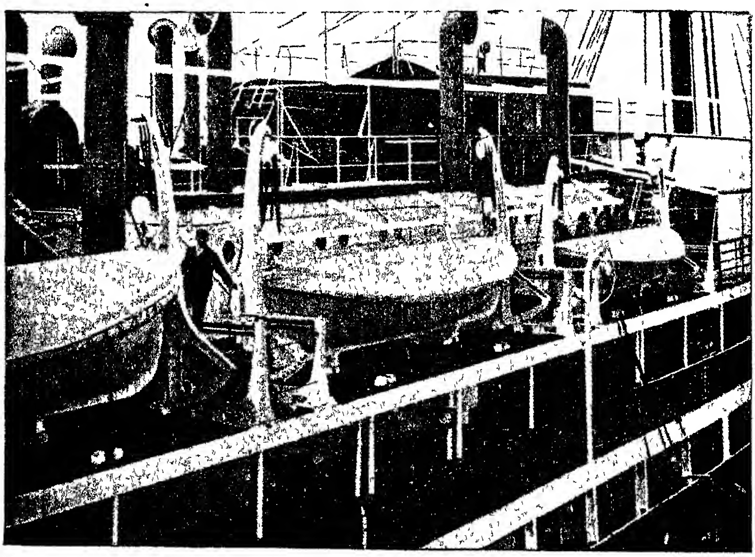


Fig 4.—Welin Quadrant Davit.

Nos. 5 and 6, one to each davit fall and lower away to the embarkation deck, Nos. 3 and 4 backing up the falls.

When everybody is embarked, lower away to the water, let go the falls and unhook the blocks. The four hands on deck slide down the life-lines or davit falls into the boat.

Crew—out oars, let go the slip painter, push off, give way together.

3. Describe how you would launch a boat with the Welin-Maclachlan Gravity Davit and three hands?

Two hands into the boat and see life-lines clear and bottom plug in.

One hand casts off the gripes, then goes to the winch brake and raises lever. The boat automatically slides down the runway and finds its

way to the embarkation deck. The end of the slip painter is then passed into the boat, and when the people are embarked the winchman lowers the boat to the water.

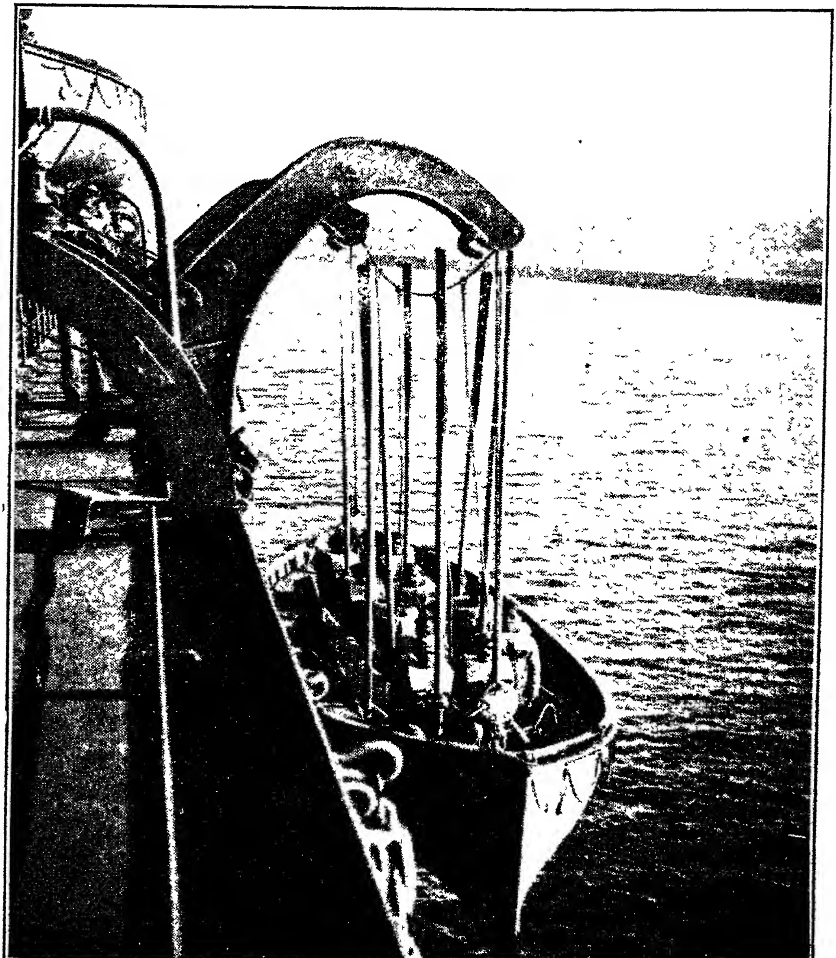


Fig. 5.—Boat being lowered to the water. Welin-Maclachlan Davit.

4. Your ship is fitted with the ordinary radial davits, describe how you would *get a boat out at sea.*

Take the cover off, remove the fore-and-after, also the spreaders.

See that all the gear is in order, and that there is nothing in the boat which is not required.

Pass a boatrope along from forward *outside* the davits, reeve it through the ring in the bow and make it fast round the forward thwart; this is better than using the painter which would have to be hauled into the boat when getting away.

Put the plug in.

Come up the gripes, take the weight of the boat, attend to the outside parts of the chocks.

Let go the guys, haul the boat aft a little and push her bow out, then hauling her forward a little, push the stern out.

Ship the rudder.

Steady the davits in their proper position by means of their guys and span.

Lower the boat down to that position where it is best and easiest for the crew and passengers (if any) to get in. The boat being manned, lower her down into the water and let go both tackles at the same time

Have the oars or sail all ready. Cast the boatrope adrift, shove off.

I should remember that a moderate breeze on board a ship is a gale of wind in a small boat, and if I thought it necessary should see that all persons had their life-jackets on.

5. How would you take her back on board again?

Give her a boatrope as she came alongside, and bring her under the davits. Leave two men in the boat, and let all the others come on board the ship.

Overhaul the tackles down, hook the forward one on first and take up the slack, then hook the after one on, and when ready hoist away on both. If the ship were at sea and rolling or if the boat were lively in a seaway, both tackles should be hooked on at the same time and the hands on deck prepared to run in the slack of the falls quickly.

When the boat is clear of the water, take the plug out to drain her out, also unship the rudder.

When high enough, belay the falls, let go the guys, and swing her inboard.

Lower carefully down on to the chocks, secure the gripes

Clean her out if necessary, see that all her equipment is in good order and that nothing is missing.

Cover her over.

6 Your ship is at sea. How would you get away from her and set sail in a boat?

Stop the ship. Clear away the lee boat and lower her down as described in "boat lowering, etc." Pass the boatrope aft along the inboard side of the boat, and when you are all ready sheer clear of the ship and let go. Out oars and pull away. Step the mast and set the sail.

If the ship was steady I should step the mast and hoist the sail before sheering away clear of her.

7. Your ship is rolling heavily How would you launch a lifeboat?

Stop the ship. At the time of lowering have the ship heading up in that direction in which she will lie the steadiest. Clear the lee boat away and have the boatrope ready as in fine weather. Get the crew in and lower her down to the level of the deck. Keep her well frapped in and held by the gunwale until a favourable opportunity comes for launching. Have oil ready for spreading if required. When the ship rolls the right way let go frappings, lower away quickly and unhook the falls. Pass the boatrope aft along the inboard side of the boat and give her a sheer off. Out oars and get a safe distance from the ship. Step the mast and set sail.

8 What are the length and size of the **davit tackle falls**?

They must be long enough to lower the boat safely into the water when the ship is floating at her lightest draught.

The size should be $3\frac{1}{4}$ to $3\frac{3}{4}$ inches for boats not exceeding 27 feet in length, and 4 to $4\frac{1}{2}$ inches for boats between 27 and 30 feet in length.

9. How would you fit **new davit tackle falls**?

Open up a coil of new rope and thoroughfoot it well. If the ship is "flying light," reeve off the fall and overhaul the tackle until the lower block nearly touches the water, cut the rope at a suitable length.

If the ship is loaded the easiest way to get the right length is by comparison with the old falls.

Should no odd falls be available, find the height of the upper blocks above the light waterline. This will give the length (very liberally) of one part of the fall. The tackles being three-fold purchases, six times this length, plus a few feet for the inboard end, will be the length of the fall.

10 Is it required that boats shall be fitted with any mechanical gear for **disengaging the falls**?

No It is not necessary when proper means are provided for detaching each fall by hand.

Mechanical disengaging gears may be fitted, but must be of a design approved by the Board of Trade. They must be so arranged as to ensure simultaneous release of both ends of the boat, and must comply with various other conditions. The hooks must also be suitable for instant unhooking by hand.

THE MOTOR LAUNCH.

The paraffin fuel tank is usually fitted in the bows of the boat under the forward deck. A small half gallon tank to hold the petrol for starting up the engine is fitted in a convenient place. Both fuel tanks are placed a little higher than the level of the cylinders so as to get a gravity feed to the engine. The petrol and paraffin can be turned on and off as required by means of a two-way cock at the engine.

Before Starting Up, the running parts in contact should be lubricated by dropping oil in the several oil holes. The bearings along the propeller shafting should be well oiled and the clutch working freely. The sea cocks of the cooling water system must be opened.

To Start Up, turn on the petrol feed, slack back the compression taps on the top of the cylinders, squirt a little petrol into each one, then tighten the taps up again. See the clutch is out. Turn the starting handle with a vigorous throw-over and this will start the engine. Allow the engine to run for a few minutes to warm up the several parts, make sure the circulating water for cooling the engine is all clear by looking at the overside exhaust. Accelerate and decelerate the engine to see that it is running all right.

To Get Under Way.—Assuming the engine is now running slowly in neutral gear I would see there were no loose ends of cordage hanging over the side to foul the propeller. Cast off mooring and go ahead steering the boat as required. Switch over from petrol to paraffin.

1. Why is it necessary to start the engine on petrol?

Because paraffin will not remain in vapour form when mixed with cold air. The vaporiser on the engine could be heated by means of a blow-lamp until the temperature of the vapour is raised to about 140° Fahrenheit when the mixture will explode. This process, however,

is slow and a nuisance. Petrol fuel vaporises at ordinary temperatures, and when the petrol and air enter the cylinders in proper proportions an explosive mixture is at once formed.

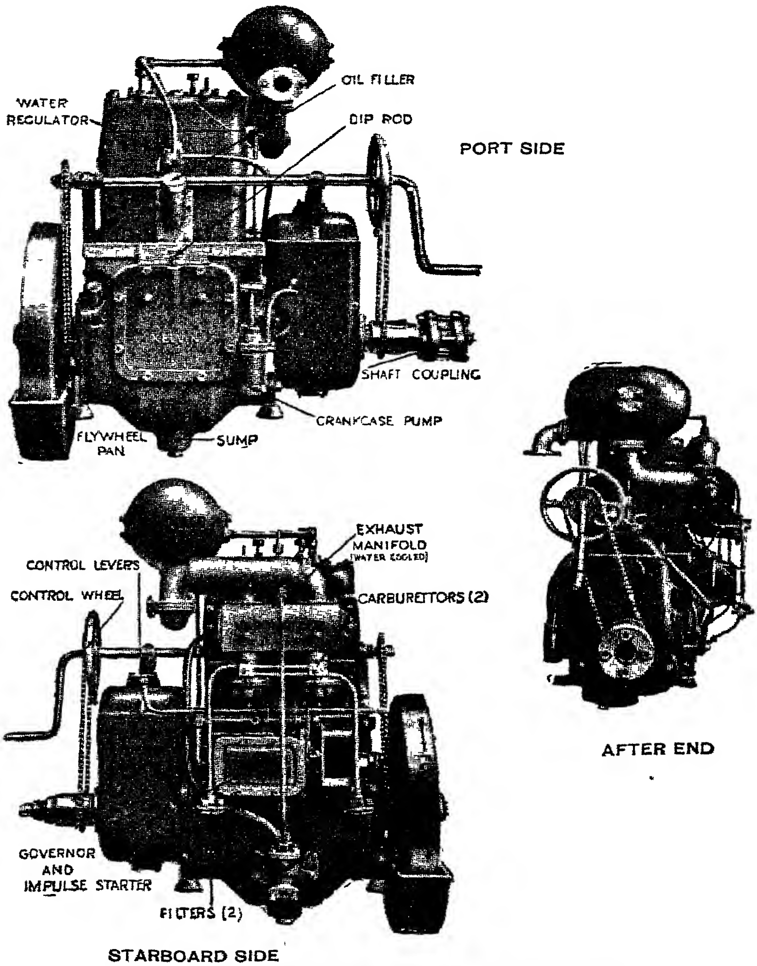


Fig. 6.—Kelvin Marine Motor for Ship's Life-boat.

Precautions.—To ensure the effective running of the engine it is desirable that the pipes leading from the fuel tanks be fitted with a fine wire gauze diaphragm to act as a strainer to keep back any sediment

that may be in the paraffin. The fuel enters the carburetter through a very minute jet and is mixed with a regulated intake of air to form an explosive mixture before entering the cylinder.

The inlet and outlet pipes of the water cooling system should also be fitted with strainers to prevent scum, weed and dirt coming in from the sea. These strainers should be cleaned occasionally. All parts should be kept as dry as possible especially the electrical equipment, the wiring of which is insulated. The engine and boat must be kept clean and no waste oil should be left in the bilge or in the drip tray under the engine. A hand fire extinguisher and a bucket of sand are kept handy to smother out quickly anything that may get ignited.

2. What is a magneto?

A magneto is a small dynamo which generates the current of electricity to provide the ignition necessary to explode the mixture in the cylinders. The current passes along the insulated wire leading from the magneto to the sparking plugs screwed into the tops of the cylinders. The distance between the terminals of the plug is called the spark gap, and the make and break contact at the magneto is so timed that ignition of the compressed vapour in the cylinders takes place at the correct moment and the explosion drives the piston. The terminals of sparking plugs get sooted up so they have to be unscrewed and wiped clean occasionally.

3. You are in charge of a motor launch, describe the procedure of manoeuvring her alongside the accommodation ladder on the starboard side of ship at anchor head to wind and tide. You are approaching the ship on her port side.

I would shape a course that would counteract the effect of the tide. This is done by watching the bearing of a stationary object and noting whether the bearing draws ahead, astern or remains the same. If the relative bearing does not alter the boat is making her course. I would pass under the stern of the ship, not too close, and head up for a position a little outside the ladder, slow down the engine by closing the throttle a little, keeping enough way on the launch to overrun the tide. When abreast of the ladder I would sheer alongside gently and get hold of the boatrope, then put the engine into neutral.

4. A man falls overboard from the launch, what action would you take to pick him up quickly?

Throw him a life-buoy, engine full astern and steer towards him.

Most motor launches can be steered with sternway on them. They are unlike a big steamer in this respect as the rudder of a small boat has a greater turning effect than the propeller The stern of a big ship invariably turns to port when going astern against the action of the rudder when put hard over.

5. Running down stream with a strong ebb tide, describe how you would bring the launch alongside a jetty situated on the left bank of the river.

I would come down on the right bank as that is the side of the fairway which will now be on my starboard side. On nearly reaching the jetty I would alter course to turn the boat's head towards it as the boat would be carried downstream when she got athwart the tide. I would then approach the jetty head on to tide, and when abreast of it, slow down the engine to stem the tide and sheer gently alongside.

MOTOR BOAT RULE OF THE ROAD.

(*To be committed to memory*)

ART. 18—When two steam vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This Article only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two vessels which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are when each of the two vessels is end on to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own; and, by night, to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply, by day, to cases in which a vessel sees another ahead crossing her own course; or, by night, to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

ART. 19.—When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

ART. 20.—When a steam vessel and a sailing vessel are proceeding in such directions as to involve risk of collision, the steam vessel shall keep out of the way of the sailing vessel.

ART. 21.—Where by any of these Rules one of two vessels is to keep out of the way, the other shall keep her course and speed.

Note.—When, in consequence of thick weather or other causes, such vessel finds herself so close that collision cannot be avoided by the action of the giving-way vessel alone, she also shall take such action as will best aid to avert collision.

1. You are in charge of a motor launch, what would you do in each of the following cases when there is risk of collision—
   (*a*) When meeting another launch end on?
   (*b*) A launch crossing on your starboard bow?
   (*c*) A launch crossing on your port bow?
   (*d*) Approaching a boat under sail so as to involve risk of collision?

Ans. (*a*) Alter course to starboard. (*b*) Keep clear by altering course to starboard. (*c*) Stand on. (*d*) Keep clear.

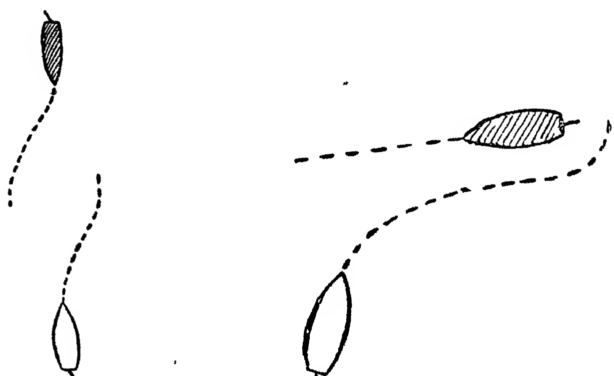


FIG 7.—(*a*) Meeting end on. (*b*) Crossing vessels

USE OF OIL FOR MODIFYING THE EFFECT OF BREAKING WAVES

The Board of Trade desire to call attention to the following information, which has been published by the Admiralty in their Sailing Directions, on the Use of Oil for Modifying the Effect of Breaking Waves:—

"Many experiences of late years have shown that the utility of oil for this purpose is undoubted, and the application simple.

"The following may serve for the guidance of seamen, whose attention is called to the fact that a very small quantity of oil, skilfully applied, may prevent much damage, both to ships (especially the smaller classes) and to boats, by modifying the action of breaking seas.

"The principal facts as to the use of oil are as follows:—

"1. On free waves, *i.e.*, waves in deep water, the effect is greatest.

"2. In a surf, or waves breaking on a bar, where a mass of liquid is in actual motion in shallow water, the effect of the oil is uncertain, as nothing can prevent the larger waves from breaking under such circumstances; but even here it is of some service.

"3. The heaviest and thickest oils are most effectual. Refined kerosene is of little use; crude petroleum is serviceable when nothing else is obtainable; but all animal and vegetable oils, such as waste oil from the engines, have great effect.

"4. A small quantity of oil suffices, if applied in such a manner as to spread to windward

"5. It is useful in a ship or boat, both when running or lying to, or in wearing.

"6. No experiences are related of its use when hoisting a boat up in a seaway at sea, but it is highly probable that much time and injury to the boat would be saved by its application on such occasions.

"At anchor, when the sea is sufficient to render it difficult to hoist up or to launch boats, oil bags from forward or from the swinging booms have been found to render the sea alongside comparatively smooth.

"7. In cold water, the oil, being thickened by the lower temperature, and not being able to spread freely, will have its effect much reduced. This will vary with the description of oil used.

"8. The best method of application in a ship at sea appears to be—hanging over the side, in such a manner as to be in the water, small canvas bags, capable of holding from 1 to 2 gallons of oil, such bags being pricked with a sail needle to facilitate leakage of the oil.

"The position of these bags should vary with the circumstances. Running before the wind they should be hung on either bow—*e.g.*, from the cathead, and allowed to tow in the water.

"With the wind on the quarter the effect seems to be less than in any

other position, as the oil goes astern while the waves come up on the quarter.

"Lying-to, the weather bow, and another position farther aft seem the best places from which to hang the bags, with a sufficient length of line to permit them to draw to windward, while the ship drifts.

"9. Crossing a bar with a flood tide, oil poured overboard and allowed to float in ahead of the boat which would follow with a bag towing astern, would appear to be the best plan. As before remarked, under these circumstances the effect cannot be so much trusted.

"On a bar with the ebb tide it would seem to be useless to try oil for the purpose of entering.

"10. For boarding a wreck, it is recommended to pour oil overboard to windward of her before going alongside. The effect in this case must greatly depend upon the set of the current, and the circumstances of the depth of water.

"11. For a boat riding in bad weather from a sea anchor, it is recommended to fasten the bag to an endless line rove through a block on the sea anchor, by which means the oil is diffused well ahead of the boat, and the bag can be readily hauled on board for refilling if necessary.

"12. Towing a vessel in a heavy sea, oil is of the greatest service, and may prevent parting the hawser. Distribute from the towing vessel forward and on both sides; if used only aft the tow alone gets the benefit."

SECTION II.—SHIP'S BOATS.

From Board of Trade Regulations

LIFE-SAVING APPLIANCES.

Details of Boat Construction.

Section Through Gunwale and Topsides

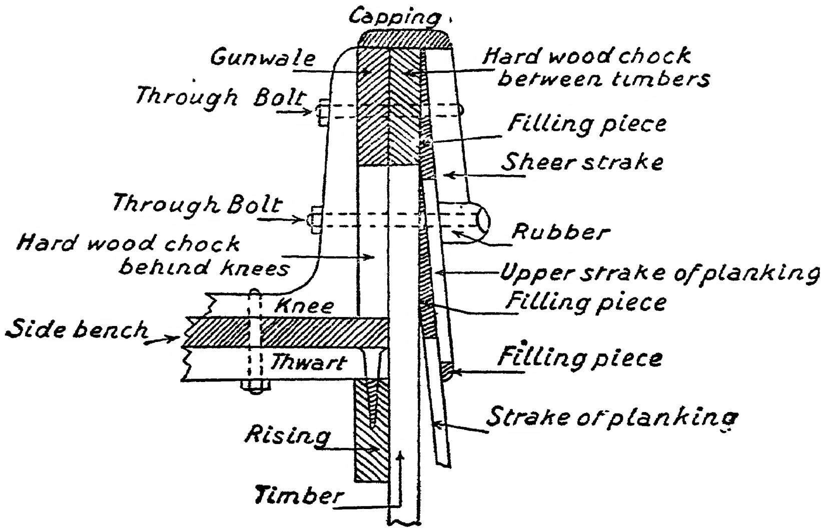


Fig. 8.

The above sketch represents a section of the gunwale and topsides of a clincher built boat, the names of the different parts being clearly indicated.

It must be understood that it shows how they would appear if the topside of the boat was cut through in a direction at right angles to her keel.

Half Midship Section of Clincher Built Boat.

Note the following parts:—

The timber.—Generally of American elm, ash, or oak. In boats of 29 or 30 feet in length the size would be about $1\frac{1}{2}\times1$ inch. Except at the ends of the boat, this is fitted in **one piece from gunwale to gunwale.**

The keel.—Of American elm or oak required to be fitted in one

piece. In boats of 29 or 30 feet in length the size would be almost 6×3 inches.

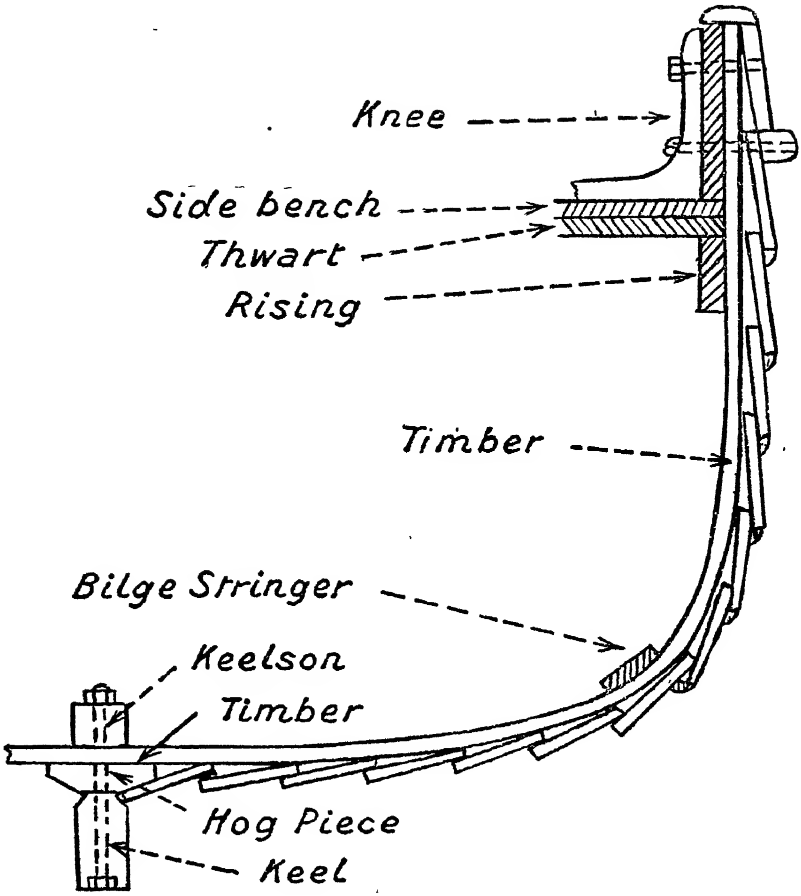


Fig. 9.

The hog piece.—Of elm or oak, about 5×1 inch in large boats.

The keelson.—Of elm, oak, or pine, about 5×3 inches in large boats.

The bilge stringer.—Of elm, larch, or pitch-pine $\frac{3}{4}$ inch thick and 3 to 4 inches wide.

The through bolt passing through keelson, hog piece, and keel.

The filling pieces underneath the landing edges of the planking.

Arrangement of Stem, Apron, Etc.

Construction of the Fore End of a Boat.

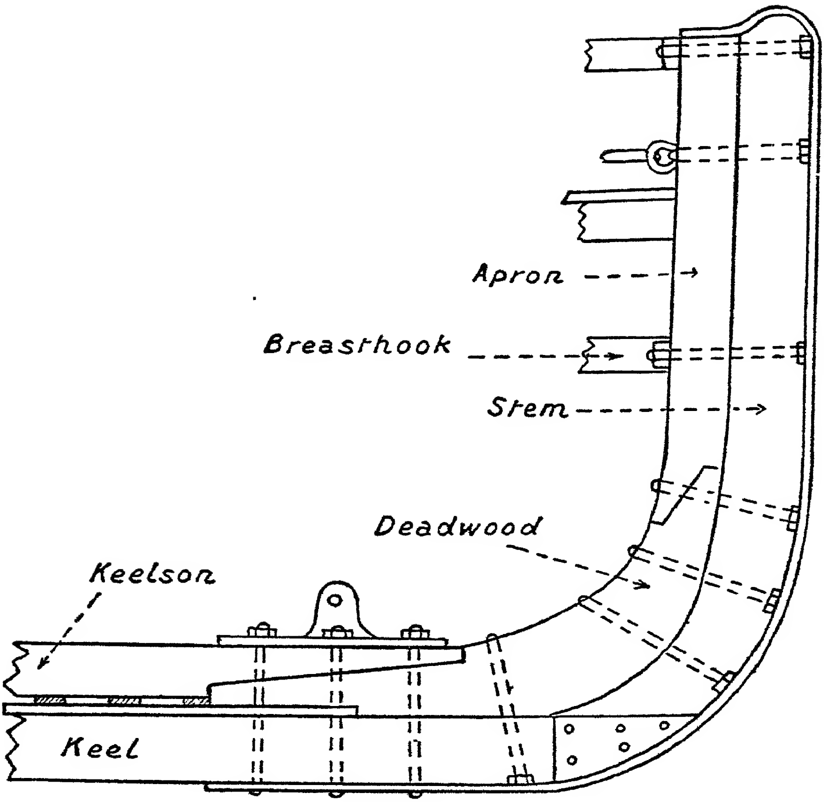


Fig. 10.

The small double line on the stem is the **iron stem band.**

The line separating the apron from the stem indicates the position of the **rabbeting** for taking the ends of the planking.

The three small shaded pieces are the **timbers**.

The fitting with the three through bolts is for the **attachment of the lifting hook.** Note that in this case the stem band is extended far enough aft to take the heads of these bolts. If not extended so far, a separate plate must be fitted.

Arrangement of the Stern.

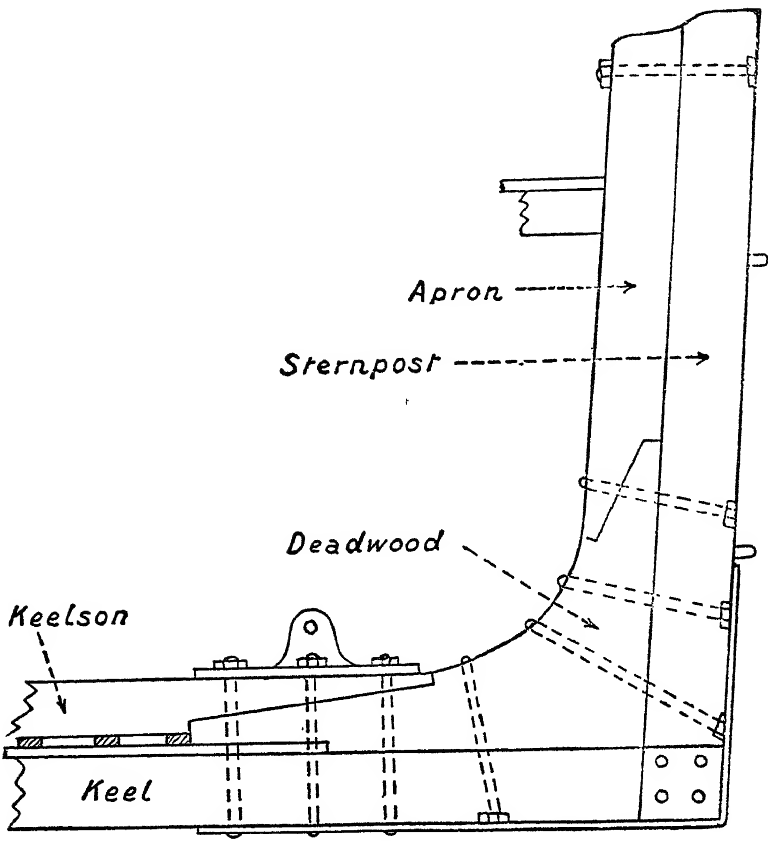


Fig 11.

The construction of the stern is very similar to that of the stem.

The line separating the apron from the sternpost indicates the position of the rabbeting for taking the ends of the planking.

Note the iron stern band. This is fitted from a point just under the lower gudgeon round the keel, under the keel, and extends far enough forward to take the three through bolts securing the lifting hook attachment.

The three shaded pieces are the timbers which lie on top of the hog piece but underneath the keelson.

Boat Construction.

1 In what way does a "**carvel built**" **boat** differ from one that is "**clincher built?**"

As regards construction, the principal and most noticeable difference is in the arrangement of the planking. In a carvel built boat the edges (and ends) of the planks butt squarely up against each other, and are not overlapped as in a clincher built boat. The planking is laid close on to the timbers, and shows a smooth flush surface both inside and outside.

In a clincher built boat, each strake of planking has a landing edge on the strake next below it. This leaves a vacant space of tapered shape inside the boat between each timber and strake of planking, and an uneven surface on the planking. It is, however, a strong system of construction on account of the many doublings formed by the landing edges of the strakes

In sailing qualities the carvel built boat is faster than the one which is clincher built, but the latter on account of the small rolling chocks formed by the plank edges is steadier in the water.

2. In what way does the procedure of building a ship differ from that of building a clincher built boat?

When building a ship, after the keel is laid the frames are erected, plumbed, and horned, and the plating is secured and riveted to the frames.

In the case of a clincher built boat, part of the procedure is reversed, that is, the planking is done first, the frames (timbers) being steamed and put in afterwards.

3. How many **thwarts** are required to be fitted in a boat?

The number depends on the length of the boat.

18 feet in length and under	4 thwarts
over 18 and not above 24 feet	5 thwarts
over 24 and not above 28 feet	6 thwarts
over 28 and not above 30 feet	7 thwarts

4. How much "**rise of floor**" is generally given to a life-boat?

Six inches in 4 feet.

5. Describe the kinds of wood which are commonly used for **planking**

Yellow pine, larch, wych elm, teak, or mahogany. It must be

of the best quality, well seasoned, free from sapwood, shakes, and objectionable knots.

6. Do the Board of Trade make any limit to the **width of the planking** in a clincher built boat?

Yes. The extreme breadth of a plank is not to exceed 5½ inches except in the four strakes next to the keel, of which two may be 7 inches, one 6½ inches, and one 6 inches.

In boats 18 feet in length and under the breadth is reduced by about 1 inch.

The landings should not be less than ¾ of an inch in breadth.

7. What is the **thickness of the planking** in a clincher built boat?

It varies between ½ and ⅝ of an inch. The eight bottom strakes (four on each side of the keel) are generally $\frac{1}{16}$ of an inch thicker than the other planks in the same boat.

8. What is the spacing of the **plank edge fastenings**?

Not less than 3½ inches. One fastening goes through each timber and one between each timber through both edges of every plank.

9. Describe the fitting of the **timbers**, and how they are secured to the planking?

The timbers are made of hard wood, 1½×1 inch in large boats, steamed and bent to shape. They are fitted on top of the hogging but underneath the keelson, and except at the extreme ends of the boat must be in one continuous piece from gunwale to gunwale

They must not be spaced wider than 6 inches centre to centre, and all fastenings must be of best wrought copper properly clenched on rooves.

In ordinary clincher built boats the timbers are secured to the planking by one fastening in each side of every plank.

10. What woods are **boat knees** made from?

Oak, ash, or elm, grown to form. Grown to form means that they must be cut from wood having a natural bend, and not from a plank, in which case some part of them would have to be cut across the grain.

11. How are the knees fitted and secured?

They are fitted above the side bench and thwart, the horizontal part being secured with a bolt passing through the three thicknesses,

also by other fastenings The vertical part is secured by two throug bolts, the lower one being worked through the rubbing piece where it head is countersunk. The knees are frequently formed of galvanise iron bar bent to an angle of 90 degrees.

12. What are the "risings?" Describe where and how they ar fitted?

The risings are fore-and-aft pieces of elm, oak, larch, or pitch-pine which must not be less than 1 inch in thickness, and 3 to 4 inches deep They are like heavy stringers fitted one on each side fore and aft, and fastened at each timber with a through fastening or brass screw. The ends of the thwarts rest upon them, and are attached to them by means of two screws at each end.

BOAT EQUIPMENT

13. What **equipment** is required for life-boats carried by foreign-going vessels?

A full single-banked complement of oars and two spare oars, also a steering oar. The steering oar should be 1 foot longer than the other oars, and the blade should be painted to distinguish it.

Two plugs for each plughole, attached with lanyards or chains.

One set and a half of thole pins or crutches, attached to the boat by sound lanyards.

A sea anchor, a bailer, and a galvanised iron bucket.

A rudder and a tiller, or yoke and yoke lines.

A painter not less than 20 fathoms in length, and a boathook.

Two hatchets.

A lantern trimmed, with oil in its receiver sufficient to burn for 8 hours.

A vessel which is to be kept filled with fresh water, and capable of holding one quart for each person that the boat is fit to carry.

A line securely becketted round the outside.

A mast or masts, with at least one good sail and proper gear for each.

An efficient compass.

An airtight case containing 2 lbs. of biscuits for each person.

One gallon of vegetable or animal oil, and a vessel of approved pattern for distributing it on the water in rough weather. This vessel shall be capable of being attached to the sea anchor.

One 1 lb. tin of condensed milk for each person the boat is certified to carry.

One dozen self-igniting red lights in a watertight tin, and a box of suitable matches in a watertight tin.

14. What is a **rowlock?**

A rowlock is a small open space on top of the gunwale made to provide a suitable place for shipping and pulling the oars in. It may be formed by pieces of wood fitted on the gunwale, or by pieces being **cut out** of the gunwale. Rowlocks are often fitted in naval boats, and in those used by fishermen and watermen, but not in boats of the Mercantile Marine. The latter are fitted with "crutches" or "thole-pins" which serve the same purpose.

15. What are the regulations relating to the **mast?**

It must be a Norway spar, the length of which is not to exceed two-thirds the length of the boat.

It should be fitted with the necessary stays and sheaves.

The sheave for lugsail halyard should be not less than 12 inches above the yard when the sail is set, and the jib halyard sheave should be not more than 12 inches below the truck.

16. What is meant by an **approved life-buoy?**

An approved life-buoy shall be of solid cork or other equivalent material. It shall be capable of floating in fresh water for at least 24 hours with 32 lbs. of iron suspended from it.

It shall be painted in good distinguishable colours such as white or red.

The inside diameter shall not be less than 18 inches.

It shall be fitted with beckets securely seized on to it. At least one on each side of the ship shall be fitted with a life-line not less than 15 fathoms in length.

17. What are the general specifications of efficient life-boats?

They must be properly constructed with materials approved by the Board of Trade, and be of such form and proportions that they have ample stability in a seaway, and sufficient freeboard when loaded with their full complement of passengers and equipment.

Their structural strength must be sufficient to permit them being

safely lowered into the water with the full complement of persor and equipment on board.

Buoyancy apparatus shall be constructed of copper or yellow meta of not less than 18 ounces to the superficial foot. The tanks are coatec with boiled linseed oil or varnish to preserve them. Boats to hav a capacity of not less than 125 cubic feet.

18. What type of boats are specified as Class 1?

There are three different types named A, B, and C.

Type A.—Open life-boats with internal buoyancy only. The buoyancy of a wooden boat of this type shall be provided by watertight air-cases, the total volume of which shall be at least equal to *one-tenth* of the cubic capacity of the boat.

Type B.—Open life-boats with internal and external buoyancy. The internal buoyancy of a wooden boat of this type shall be provided by watertight air-cases, the total volume of which shall be at least equal to $7\frac{1}{2}$ *per cent* of the cubic capacity of the boat.

If the external buoyancy is of cork, its volume for a wooden boat shall be not less than *thirty-three thousandths* of the cubic capacity of the boat; if of any material other than cork its volume and distribution shall be such that the buoyancy and stability of the boat are not less than that of a similar boat provided with external buoyancy of cork.

In the case of a metal boat of both A and B types, an addition shall be made to the cubic capacity of the airtight compartments so as to give it buoyancy equal to that of the wooden boat.

Type C.—Pontoon life-boats having a well deck and fixed watertight bulwarks. The area of the well deck of a boat of this type shall be at least 30 per cent. of the total deck area. The freeboard shall be such as to provide for a reserve buoyancy of at least 35 per cent.

19. What type of boats are specified as Class 2?

There are three different types named A, B, and C.

Type A.—Open life-boats having the upper part of the sides collapsible. A boat of this type shall be fitted both with watertight air-cases and with external buoyancy, the volume of which for each person which the boat is able to accommodate shall be at least equal to the following amounts:—

Air-cases - - - -	1·5 cubic feet.
External buoyancy (if of cork)	0·2 cubic feet.

The freeboard of boats of this type depends on their length, and in fresh water shall not be less than the following amounts:—

Length of the boat in feet.	Minimum freeboard in inches.
26	8
28	9
30	10

Type B.—Pontoon life-boats having a well deck and collapsible bulwarks. All the conditions laid down for boats of Class 1, C, shall be applied to boats of this type, which differ from those of Class 1, C, only in regard to the bulwarks.

Type C.—Pontoon life-boats having a flush deck and collapsible bulwarks. The minimum freeboard of boats of this type is independent of their length, and depends only on their depth. The freeboard in fresh water shall not be less than the following amounts:—

Depth of the boat in inches.	Minimum freeboard in inches.
12	$2\frac{3}{4}$
18	$3\frac{3}{4}$
24	$5\frac{1}{8}$
30	$6\frac{1}{2}$

20. What type of boats are specified as Class 3?

Open boats which have not the buoyancy required for life-boats of Class 1.

21. **How many boats** are required to be carried by a foreign-going steamer?

Such number, and of such aggregate capacity as shall be sufficient to accommodate the total number of persons which is carried, or which the ship is certified to carry, whichever number is the greater.

When the number of life-boats is more than 10, one of them shall be fitted with an approved wireless telegraphy installation.

When the number of life-boats is more than 13, one shall be a motor boat; and when the number is more than 19, two shall be motor boats.

All motor boats shall be fitted with wireless telegraphy and searchlights.

22. **How many sets of davits** are required to be carried by a foreign-going passenger steamer or emigrant ship?

The number of sets of davits depends upon the length of the vessel. Subject to various modifications, a few examples are given below:—

Registered length of ship in feet.			Minimum number of sets of davits.
100	and under	160	2
160	„	190	3
190	„	220	4
300	„	330	8
370	„	410	10
460	„	520	14
640	„	700	20
960	„	1030	30

Provided that no ship shall be required to have a number of sets of davits greater than the number of boats required to accommodate the total number of persons which is carried, or which the ship is certified to carry, whichever number is the greater.

23. How would you find approximately the *cubic capacity* of an open life-boat?

Measure the length and breadth outside and the depth inside, in feet. Multiply them together and by ·6; the product may be assumed to be the capacity of the boat in cubic feet.

The formula would be written down, $L \times B \times D \times \cdot 6 =$capacity; where L=length, B=breadth, D=depth (all in feet).

24. Find the cubic capacity of an open life-boat which has measurements of 24 feet by 7 feet 6 inches by 3 feet.

```
Length    24  feet
Breadth    7·5 feet
          ----
          120
         168
         -----
         180·0
            ·3 depth
         -----
         540·0
            ·6
         -----
         324·00 cubic feet
```

25. How would you determine the number of persons which a life-boat is fit to carry?

By finding her cubic capacity in feet, and dividing it by 9 in the case of boats of Class 1, B, but by 10 in the case of all others.

26. A life-boat has a cubic capacity of 360 feet. How many persons is she fit to carry?

If of Class 1, B, she will carry 40 persons, if of any other class she will carry 36 persons.

27. Is a life-boat **required to be marked** in any particular way?

Yes. All boats shall be permanently marked in such a way as to indicate plainly their dimensions and the number of persons for which they are approved. The marking should be cut on the stem or sheer-strake on one side of the boat, and the number of persons for which they are approved should be cut on the other side.

28. What is meant by a boat's "coefficient of fineness"?

The ratio which the cubic capacity of the boat bears to the cubic capacity of a rectangular block of the same extreme dimensions. Its value which is generally about ·6 gives some idea of her shape and the fineness of her lines. If she was round in the counter and bluff in the bow her coefficient of fineness would be greater than ·6, if of very fine lines it would be less.

29. **How many life-buoys** are required by a foreign-going passenger steamer?

The number depends on her length.

If she is under 400 feet in length, at least 12.

If 400 but under 600 feet in length, at least 18.

If 600 but under 800 feet in length, at least 24.

If 800 feet or over, at least 30.

At least half the number of life-buoys required to be carried shall have self-igniting life-buoy lights placed near them, and such lights are to be provided with means for attachment to the life-buoys.

One life-buoy must be carried in beckets or cleats on each side of the navigating bridge in such a manner that they can be instantaneously released, and will drop clear of the ship's side. Each of these life-buoys shall have a self-igniting lifebuoy light attached to it by at least 12 feet of good line. Two buoys, one on each side, to be fitted with life-lines 15 fathoms in length.

30. How many life-buoys are required to be carried by a foreign-going steamer not certified to carry passengers?

Not less than six At least half the number shall have self-igniting life-buoy lights placed near them, such lights to be provided with means for attachment to the life-buoys.

One life-buoy must be carried on each side of the navigating bridge, and must be fitted in exactly the same way as in passenger steamers.

31. Give a brief description and specification of a **life-jacket.**

A life-jacket is a life-saving appliance to be fitted on the wearer's body, and secured in position by means of tapes.

The required buoyancy may be supplied by cork, kapok, or other approved substance, but must not depend on air compartments.

The covers may be of cotton, linen, or other approved material.

The tapes, two in number, must be of linen or cotton thread web 1¼ inches wide, not less than 110 inches long. They must be capable of bearing a strain of 200 lbs.

The sewing must be done with good quality thread, the ends of the stitching being securely finished off.

The weight of a Standard kapok life-jacket should not exceed 2 lbs. 4 ozs., and the weight of a Standard cork life-jacket should not exceed 5 lbs. 4 ozs.

The buoyancy must be so distributed that when the wearer is inert in the water the position of the body should be as near the vertical as possible.

It should be so arranged that it will keep the wearer's head clear of the water when floating in the inert position.

In the event of the wearer being rendered unconscious, the head should be so supported that it would not fall forward and the face become submerged.

The jacket must be reversible, *i.e.*, it must satisfy the above conditions even if it is adjusted on the wearer back to front or upside down.

32. What is meant by an **approved life-jacket?**

An approved life-jacket shall mean a jacket of approved material and construction which is capable of floating in fresh water for 24 hours with 16½ lbs. of iron suspended from it, or any other approved appliance of equal buoyancy and capable of being fitted on the body.

33. Who is responsible for seeing that all passengers and all members of the crew are properly instructed in the adjustment of the life-jackets on board?

The master.

34. How many life-jackets are required to be carried by a foreign-going steamer?

One approved life-jacket for every person on board, and if a passenger steamer an additional and sufficient number of approved life-jackets of a suitable size for children.

35. Who has the authority for appointing officials to inspect life-saving appliances?

The Board of Trade. These officials are called Board of Trade Surveyors (or inspectors).

36. May a ship surveyor inspect a ship's life-saving appliances?

Yes. And for the purpose of that inspection he shall have all the powers of a Board of Trade inspector.

37. What general precautions (as regards her life-saving appliances) are to be taken to ensure, as far as possible, the safety of a vessel's passengers and crew?

Passengers and crew should be properly instructed in the use of the life-saving appliances provided for them.

Life-jackets for every person on board must also be kept in some known place where they are always readily accessible.

All life-saving appliances must be periodically examined for the purpose of seeing that they are fit and ready for use.

An officer told off for the purpose shall be responsible for examining all the boats and their equipment once a week.

In foreign-going passenger ships musters of the crew shall be held at least once a week when practicable either in port or at sea. (Once a fortnight in cargo ships.)

Muster lists showing the stations and duties of each member of the crew shall be posted up in the crew's quarters and other conspicuous places.

Sufficient members of the steward's department are to be told off for the effective mustering of passengers.

Boat drill must be practised. The master must enter in the official log book a statement of every occasion on which boat drill is

practised on board the ship and on which life-saving appliances have been examined. Penalty for failing to comply with this requirement, **a fine not exceeding £10.**

38. Is the master liable to any other penalty for breach of rules regarding life-saving appliances?

Yes. If he is in fault he is liable to **a penalty of £50,** and the owner if in fault is liable to a penalty of £100 for any of the following offences:—

If the ship proceeds on any voyage without being supplied with life-saving appliances in accordance with the rules applicable to the ship, or

If any of the appliances with which the ship is so provided are lost or rendered unfit for service through the wilful fault or negligence of the owner or master; or

If the master wilfully neglects to replace or repair on the first opportunity any such appliances lost or injured in the course of the voyage; or

If such appliances are not kept so as to be at all times fit and ready for use.

39. What points have to be considered when deciding upon the positions in which boats are to be carried and lowered?

They should be carried in positions where they are easily accessible, and can be manned and lowered quickly, the safe embarkation of passengers being carefully studied.

They must be high enough above the water to ensure them being reasonably safe from damage in bad weather.

They should not be placed where, when being lowered into the water, there is any chance of them being swamped by water from condenser or pump discharges.

Projections on the ship's side must also be considered, and positions chosen where such projections (if any) are small and not liable to prove dangerous.

Where this is impracticable, dangerous projections should be removed or modified in design. If this cannot be done, all boats which are stowed above such projections must be fitted with efficient **vertical** fenders.

When boats are lowered care must be taken that they are not in dangerous proximity to a propeller.

40. What is done to guard against the edges of the planking being caught by the edges of the ship's plating when a boat is being lowered?

The overhang of davits must be such as will admit when the vessel is upright of a minimum clearance in lowering of 1 foot between the ship's side and that of the boat. When the ship is fitted with a heavy "rubber" or "belting" the clearance must not be less than 6 inches.

"Filling pieces" of curved form on the outside are also fitted to the boat underneath the landing edges of the planking for about one-third of her length amidships. These extend from the bilge to the gunwale, and are a further safeguard.

The men in the boat would also assist in keeping her clear of the ship's side.

41. Describe the sea anchor of a life-boat?

It consists of a bag made of good quality canvas formed in the shape of a cone. The mouth of the bag has a diameter of between 2 feet and 2 feet 6 inches, and is kept open by being sewn round a galvanised iron or wooden ring. A double bridle is spliced round this ring in four places, eyelet holes at equal distances apart being made in the canvas for this purpose. To the bights of this bridle 15 to 20 fathoms of $2\frac{1}{2}$-inch rope are secured to act as a cable. A small opening is left at the point of the sea anchor through which some water escapes as the boat slowly drives to leeward. A tripping line of light stuff is spliced into a becket also at the point of the sea anchor for the purpose of hauling it in. *See* figure 8, page 119.

CHAPTER VII.

ANCHORS AND CABLES.

Anchors are made of forged wrought iron, or forged open hearth ingot steel, or cast steel and are marked on the crown (or head) and shank showing the maker's name or initials, progressive number, and weight. All anchors are tested as to their strength, the strain imposed on them varying with their size.

All *cast* steel anchors are also subjected to percussive, hammering, and bending tests. They must also be annealed and stamped "Annealed Steel."

All steamers, except very small ones, have to carry two bower anchors, also one spare bower anchor, and a stream anchor. Sailing vessels have to carry the same, with a kedge in addition. The stream anchor is about one-third the weight of the bower.

The spare anchors are stowed and well secured in some convenient position where they can easily be got at. The spare bower is carried on the forecastle-head or fore deck. In steamers where it is likely to be required for stern moorings, the stream anchor is generally carried aft.

Some vessels have been fitted with a windlass, stream chain and a hawsepipe at the stern when specially equipped for trading to ports where stern moorings are required.

The principal parts of an anchor are shank, crown, arms, flukes or palms, bills or peas, stock, ring or shackle, forelocks. (*See* illustrations on next page.)

The weight of a steamer's anchors depends on the size and type of the vessel. The following is a rough approximation. In some cases one bower and the spare bower may be less than the given weights.

Length of vessel (in feet)	Bower anchors without stock (in cwts.)	Stockless anchors (in cwts.)	Stream anchor without stock (in cwts.)
290	28½	35½	9¼
375	42	52½	14
480	65	81¼	23½

In small steamers the anchors will be lighter, and in very large steamers much heavier than the weights given above.

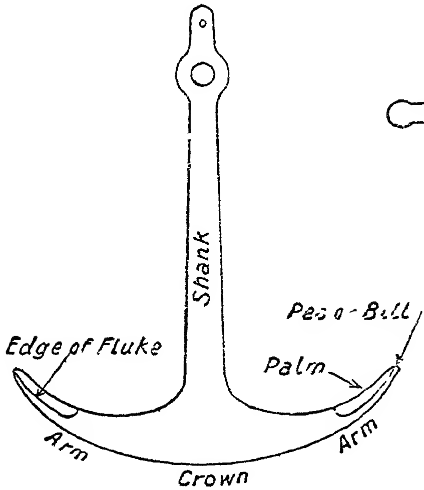


Fig. 1.

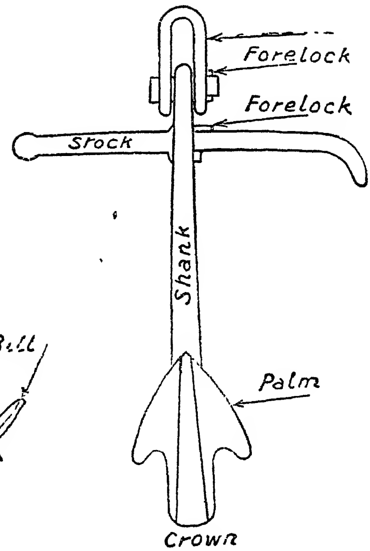


Fig. 2.

The anchor stock must be equal to one-fourth the specified weight of the anchor. It will be noted that this brings the weight of the anchor **with** stock up to approximately the same as the stockless anchor. The stock is to help the anchor to bite and get a good hold of the ground. Should the anchor fall with its arms flat, the stock will be upright, and as soon as any weight comes on the cable, the stock being heavy and longer than the arms, **it will turn the anchor**. This is the best holding type of anchor and the longer the shank the better it holds; it is, however, awkward to handle and stow on the forecastle-head.

Stockless Anchors.—Figure 3 shows a Lenox unchokeable stockless anchor; this type of patent anchor is now universally adopted in modern steamships. It consists of a heavy head having arms and flukes generally forged in one piece with it, also a shank and shackle.

The head is made to turn on an axis perpendicular to the shank, the arms moving in a plane parallel to the shank, being in line with it when in the closed position.

It is so constructed that the head will turn on its axis and the arms will open out to an angle of 45° with the shank, but no further.

The head must weigh not less than three-fifths of the total weight of the anchor.

When the anchor is let go, the strain on the cable causes the arms to open out and the flukes to bite into the ground.

The advantage of a stockless anchor over one fitted with a stock is in the ease of handling it, and the amount of work which is saved

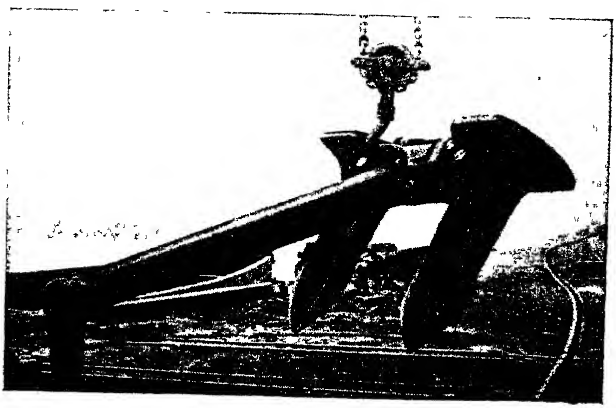


Fig. 3 —Patent Stockless Anchor.

by its use. Instead of having to be taken on board by a crane, and bedded and secured every time the anchor is lifted, it is hove right up into the hawsepipe and remains there. If the anchor is likely to be required again shortly it would be held by the windlass well screwed up, or by the chain being put in the bow stopper from which it could be quickly released. If not, it could be hung off with the "devil's claw" or a chain stopper, or chain lashing.

Fig. 4.—Bow Stoppers.

A stout iron-bar passed through the big link or any other link in the cable, and resting on the top of the hawsepipe, would also hold it and be a safeguard against accident.

Permanent Mooring Anchors for buoys and beacons in shallow water have usually one fluke only and the anchor is lowered to the

bottom fluke downwards, by means of a slip rope rove through a shackle in the crown. A screw mooring is sometimes used for the same purpose.

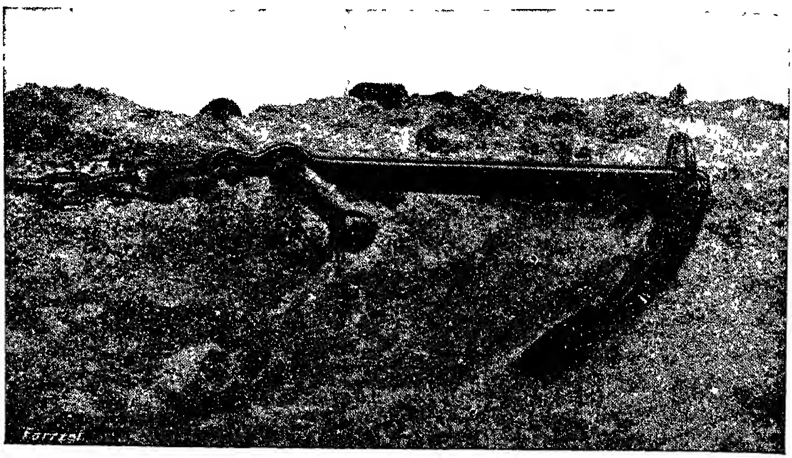


Fig. 5.—One Fluke Mooring Anchor.

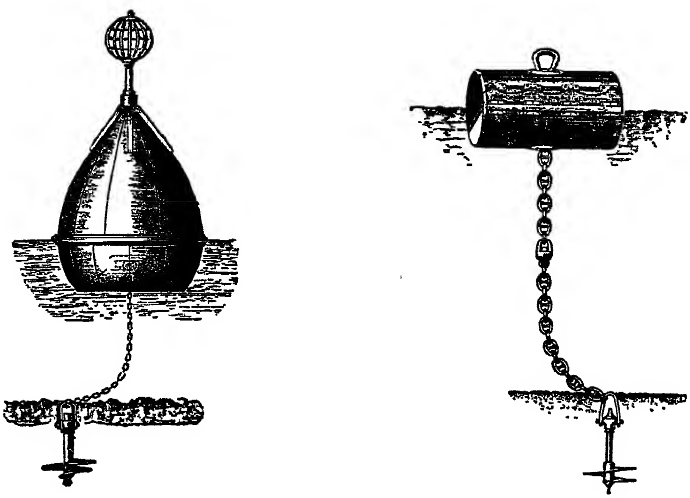


Fig. 6.—Screw Moorings.

Lightvessels round the coasts are generally moored with two mushroom anchors which bury themselves in the bottom. The cables from each hawsepipe are shackled to the upper links of a swivel

and the cables from each mushroom to the lower links. The swivel turns when the vessel swings round to the tide and so prevents the cables twisting round each other thus ensuring a "clear" hawse.

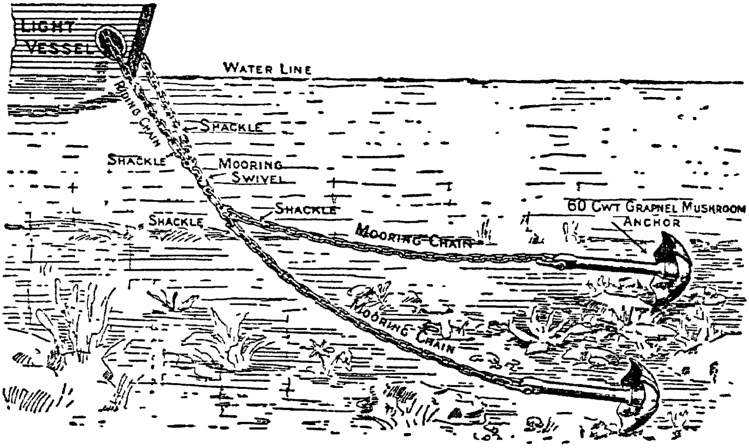


Fig 7.—Mushroom Anchors.

A Sea Anchor is simply a tapered canvas bag the small end being also open. It is part of the compulsory equipment of ships' life-boats and is thrown out ahead of the boat with a line attached to the bridle to keep the boat head on to wind and sea when it is impossible to make headway against the wind. A small canvas bag with needle holes

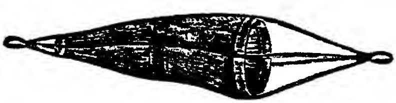


Fig. 8.—Sea Anchor.

punctured in it and filled with oil is lashed to the sea anchor, and the oil, spreading on the surface of the water, helps to smoothen the sea in the track of the boat and makes conditions more comfortable.

Chain Cable is measured by the diameter of the iron forming the links. Studs are fitted in the links to keep chain from kinking and, incidentally, they add to its strength. The size of cables for a steamer depends upon the size and type of the vessel. The following table

will give an approximate idea as to both size and length of chain provided.

Length of steamer in feet.	Length of cable in fathoms	Size of cable in inches
290	240	$1\frac{1}{4}$
375	270	$2\frac{1}{16}$
480	300	$2\frac{1}{2}$

Larger steamers have longer and heavier cables. The *Mauretania* has 330 fathoms, the size being $3\frac{3}{4}$ inches.

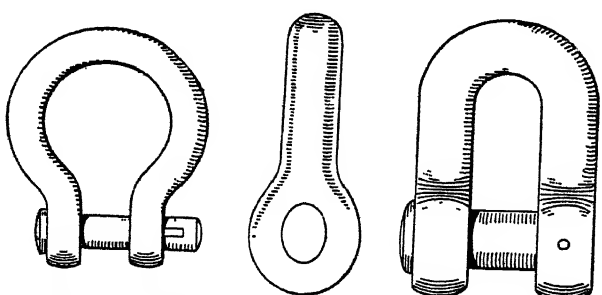
The cables of sailing ships are heavier, and they carry 30 fathoms more than steamers of corresponding size.

Lloyd's Rules regulate the sizes of all anchors and cables for **both steam and sailing vessels according to their equipment number.** This is their longitudinal scantling number with an allowance for superstructures added to it. The corresponding approximate lengths quoted above have been given here, as they are more easily noted and understood.

The length from shackle to shackle in the cable is 15 fathoms in merchant ships, $12\frac{1}{2}$ fathoms in warships; the shackles being placed in the cable with the bow or round end of the shackle forward so that it goes out first.

SHACKLES.

The shackles which join the lengths of cable together differ slightly from those used for shackling it to the anchor. In the joining shackles



Anchor Shackle. Joining Shackle.

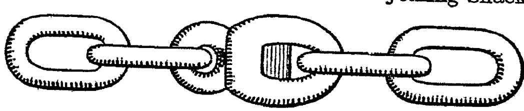


Fig. 9.—Swivel Link.

the pin does not project beyond the width of the shackle, and is secured by a hard wood plug passing through the pin and one lug of the shackle. The anchor shackle is larger than the joining shackles, and the pin projects through the lug on one side, being secured by a ring or forelock. In some of the latest ships there is no difference.

The lengths of cables are marked in succession as follows:—At the first shackle (15 fathoms) by a piece of seizing wire on the stud of the first link abaft the shackle; at the second shackle (30 fathoms) by a piece of wire on the second studded link abaft the shackle; at the third shackle (45 fathoms) by a piece of wire on the third studded link, and so on.

All the marked links are sometimes painted white so that they may be more easily noted when the cable is running out.

Fig 10.—Senhouse Slip.

The inboard end of the cable is generally shackled to a good eyebolt in the collision bulkhead at the bottom of the chain locker. A lashing of small chain is sometimes used, and is better than the shackle as it can easily be let go in case of emergency, although a Senhouse slip link is best.

INSPECTION OF ANCHORS AND CABLES.

Vessels undergo a periodical survey every four years by one of the two classification societies, Lloyd's or the British Corporation, under which British vessels are registered. The hull, machinery and deck equipment are then inspected. The chain cables are ranged for inspection and anchors and chains examined and placed in good working order. If any length of chain cable is found to be reduced in mean diameter by 10 per cent. of its original size at its most worn part it is to be renewed. The chain locker is examined internally.

The cable is ranged in long lengths up and down the bottom of the dry dock, pins of shackles knocked out and examined, coated with white lead and tallow and replaced with new wooden holding pins driven into the pins of the connecting shackles. The links are sounded

by tapping with a hammer to hear if they give out a clear ring. It is desirable to occasionally replace the two or three lengths next the anchor with two or three lengths from the bottom of the locker as all chain gets fatigued and brittle when lying idle. This also gives an opportunity of cleaning out the locker. When dirty cable is being hove up from a muddy bottom it should be hosed down as it enters the hawse-pipe. It may be remarked here that at each survey the masts, spars, rigging and general deck equipment are inspected, including hatch covers and supports, tarpaulins, cleats and battens, ventilator coamings and covers.

The Anchors and Chain Cables Act insists on rigorous tests being applied to mooring cables, the responsibility for their efficiency, in the first instance, being on the maker. The chain is made in 15 fathom lengths with three additional experimental links; the sample links and the length of cable must each be stamped with a distinctive identification number.

The cable is taken to a testing establishment licensed by the Board of Trade, and the three links cut out and submitted to the full breaking strength, but only the proof test, which is about 70 per cent. of the tensile breaking strength, is applied to the 15 fathoms length. The breaking load is about 24 D^2, D being the size of the cable chain in inches. After it has been tested the length of chain is measured for elongation and each link separately examined by two inspectors for flaws, cracks, broken or twisted studs, etc. The cable when passed is stamped with the Board of Trade test marks and a full description of its length, weight, size of the links and shackles and a record of the tests, makers' name, ship's name, etc., are recorded on the Cable Certificate which must be carried on board the ship and produced when required.

A drop test is applied to anchors. The anchor is raised so that its lowest part is at a height of 12 feet and then dropped on a steel or iron slab. It is dropped side on, and then end on, and if this percussive test is satisfactory the anchor is then slung up and hammered all over with a 7 lb. sledge hammer to see if it gives a clear ring. This test is to ensure that there are no flaws in the casting and that none have been developed by the drop tests.

The anchor when passed at a Lloyds Proving House licensed by the Board of Trade is stamped with the Identification Mark of the Proving House, the Certificate Number, the Number of the Tensile Machine; Year Licence was granted; Proof Strain.

Chain cables are stamped at every five fathoms with the same information as for anchors and in addition the tensile and breaking strains.

Spare Parts for Rod and Chain Steering Gear: By Agreement between the Shipping Federation and the Ministry of Shipping.

Ships under 12 knots.—

1 complete spring buffer and 1 spare spring.

2 tested chains equal to the longest length in the gear or, alternatively, 1 spare set of all the lengths on one side.

2 bottle screws; 2 sheave pins.

4 shackles; 4 connecting links, 4 rod pins.

Ships over 12 knots and all H.T. Ships and Coasting Vessels.—

1 tested chain equal to the longest length in the gear.

1 spring buffer, 1 bottle screw.

4 shackles; 4 connecting links; 4 rod pins.

2 sheave pins.

QUESTIONS.

1. What materials are anchors made of?

2. What marks are stamped on anchors after having been tested?

3. Describe the anchors carried by a steamer, where stowed and their special purpose.

4. Name the parts of an anchor fitted with a stock, and also the parts of a stockless anchor.

5. What was the weight of the anchors in any ship you have served in and the length of her cable chains?

6. Discuss the advantages and disadvantages of stock anchors and stockless anchors.

7. Describe any forms of permanent mooring anchors you may know of.

8. How may a patent anchor be securely held in the hawsepipe?

9. Who prescribes the size of anchors and cables a ship must have?

10. How are successive lengths of cable marked?

11. A new cable is brought to the ship: how can one tell which is the chain locker end?

12. State what should be done occasionally with chain cables, shackles, chain locker and anchor gear generally in order to preserve them as much as possible.

13. State what you know of the Anchors and Chain Cables Act.

CHAPTER VIII.

DECK APPLIANCES AND APPARATUS.

Communication throughout a small ship is easily maintained by the human voice, but the larger the ship the more difficult does it become to maintain the rapid and effective transmission of imperative orders from the navigating bridge to the various parts of the ship. The engine and docking telegraphs, telephones and the various signalling devices to indicate the position of watertight doors, the failure of navigation lights, the overheating of a compartment or the outbreak of fire, are installed in the wheelhouse which, in effect, is the nerve centre of the vessel.

Mechanical Telegraphs.—Orders are transmitted from the bridge to the engine-room by means of a wire and chain telegraph The dial casing covers a sprocket wheel keyed to a horizontal axle; the end of the axle projects through the centre of the dial and is firmly attached to a hand lever. When the lever is moved the wheel turns through a corresponding arc of a circle. The links of a flat chain, similar to the driving chain of a bicycle, engage with the sprockets of the wheel and the ends of the chain which hang down inside the pillar, are connected by means of tightening screws to wires led in the most convenient and direct way to a similar telegraph in the engine-room (Fig. 1).

In the event of the bridge and engine-room telegraphs not registering the same command it would be necessary to unscrew the brass panel on the pillar of the bridge telegraph, slacken back one of the connecting screws and tighten the other one until the reply pointer and the command pointer came together.

The dial is marked AHEAD and ASTERN for "Slow," "Half," "Full" and also "Stand By," "Stop," "Finished with Engines." When the lever is moved to half ahead the pointer on the engine-room telegraph also moves to half ahead and a bell rings to attract attention. The engineer then replies by moving the lever of his telegraph to half ahead and by doing so operates the return pointer on the bridge telegraph which rings a bell, thus indicating to the officer that the order has been understood and is being executed.

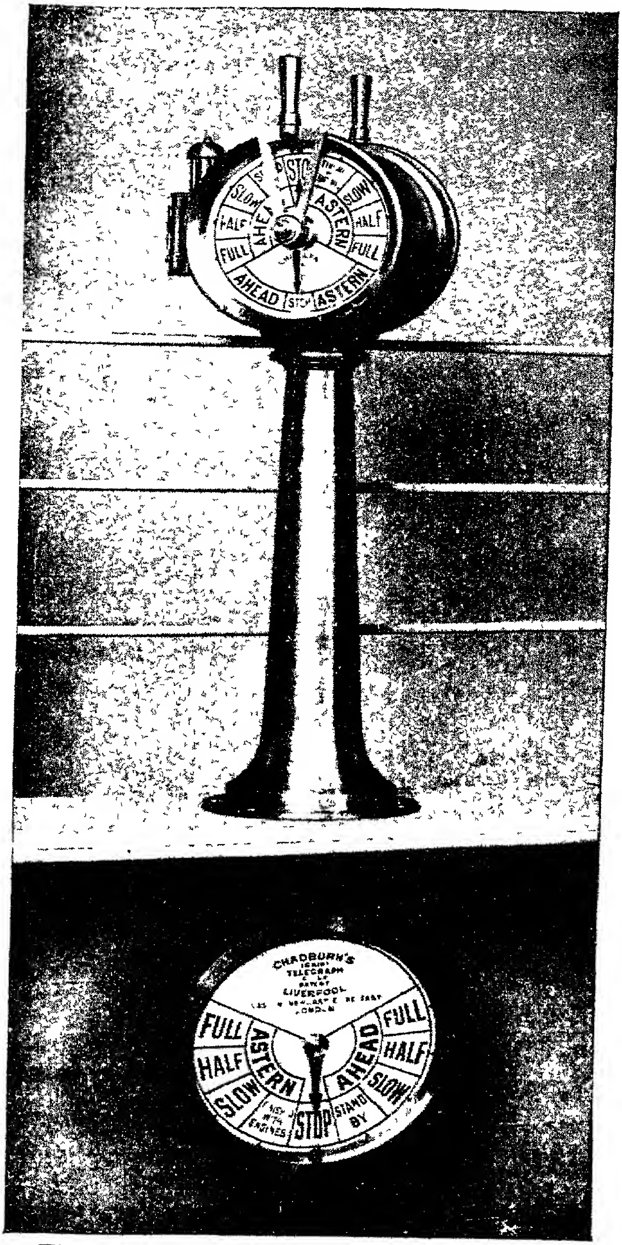


Fig. 1.—Bridge and Engine-room Telegraph.

Docking Telegraphs are fitted in big ships, usually one at the stern and sometimes another at the bow. They are geared to their corresponding telegraphs on the bridge in the same way as the engine-room telegraph. The dials are marked so as to distinguish clearly between the mooring ropes on the starboard side and those on the port side as indicated in the adjoining illustration which, in this case, admits of the following orders being transmitted from the bridge to the officer attending to the mooring of the ship.

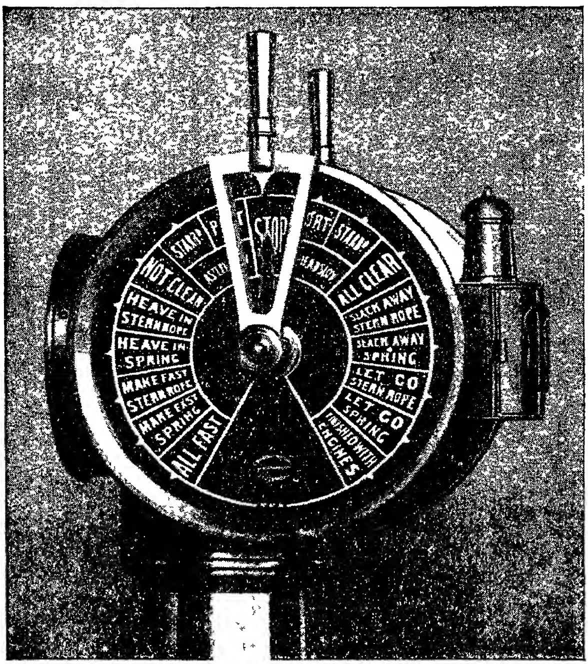


Fig. 2 —Docking Telegraph.

Astern	Ahead
Not Clear	All Clear
Heave in Stern Rope	Slack away Stern Rope
Heave in Spring	Slack away Spring
Make fast Stern Rope	Let go Stern Rope
Make fast Spring	Let go Spring
All Fast	Finished with Engines

It is the usual practice when docking to station the third officer on the bridge to work the telegraphs as instructed by the captain or pilot, the first officer at the fore end of the ship to work the forward hauling lines, mooring wires and anchors, and the second officer at the stern.

In some passenger ships, however, the stations of the first and second officers are reversed for the reason that the more experienced and responsible officer is required at the stern as he is far removed from the bridge and is usually hidden by deck erections from the sight of those on the bridge, whilst, on the other hand, the bridge being well forward, the officer in charge of the operations on the forecastle-head is in full view from the bridge.

A Steering Telegraph, or Telephone, is sometimes fitted to transmit helm orders from the flying bridge down to the wheelhouse, and also telegraphs for communication between the engine-room and stokehold regarding the firing of boilers.

A Navigation Light Sentinel is an apparatus which rings an alarm bell should any of the navigation lights fail. It is electrically wired to the masthead lights, side-lights and stern light, and should any one of them go out a coloured disc in the indicator mounted in the wheelhouse shows which particular light has failed to function.

THE LEADLINE.

The Hand Lead is about 7 or 8 lbs. in weight, and is for use in shallow waters, or in channels or rivers, etc., where it is necessary to take soundings frequently at short intervals, and without stopping. Proficiency in heaving the hand lead can only be attained by considerable practice. It should be hove on the weather side in a sailing ship; in steamers or in vessels being towed it should be hove on the side on which the shallowest water is expected.

The hand leadline is long enough to allow of soundings being taken with it up to 20 fathoms, and is marked as under:—

At	2 fathoms	- -	2 ends or strips of leather.
,,	3 ,,	- -	3 ,, ,, ,,
,,	5 ,,	- -	White rag (linen).
,,	7 ,,	- -	Red rag (bunting).
,,	10 ,,	- -	Leather with a hole in it.
,,	13 ,,	- -	Blue rag (flannel or serge).
,,	15 ,,	-	White rag (linen).
,,	17 ,,	- -	Red rag (bunting).
,,	20 ,,	-	Cord with 2 knots in it.

The fathoms 1, 4, 6, 8, etc , at which there are no marks are called "deeps," but very often these are marked with short ends of marline There are thus 9 *marks* and 11 *deeps* on the hand leadline In order that the marks may be distinguished by feeling them, linen is used for the white, bunting for the red and serge for the blue rag.

In marking a new line it should be opened out, and an eye spliced in the end large enough to slip over the lead, and then stretched and soaked. To be strictly correct, the first measurement should be taken from the end of the lead, but it is usually measured from the end of the line, in order to give the ship what is termed the "benefit of the lead." That is to say, there is then a very slight error on the safer side. It would be very dangerous to have marks too short, as it would indicate the water to be deeper than it really was.

The markings of both the hand and the deep-sea leadlines should be verified before use, and the line should be soaked first.

CALLING THE SOUNDINGS.

When the leadsman calls the soundings, he should always make the number of fathoms the *last* part of the call. By so doing the officer will generally get the *number of fathoms*, even though, through wind or other causes, the first two or three words are not distinguished.

The report should be made as follows:—

At a depth of	6	fathoms	- -	by the deep 6.
"	6¼	"	- -	and a quarter 6.
"	6½	"	- -	and a half 6.
"	6¾	"	- -	a quarter less 7.
"	7	"	- -	by the mark 7.
"	7¼	"	- -	and a quarter 7.
"	7½	"	- -	and a half 7.
"	7¾	"	- -	a quarter less 8.
"	8	"	- -	by the deep 8.
"	8¼	"	- -	and a quarter 8. And so on.

THE DEEP-SEA LEAD.

The Deep-sea Leadline is marked similarly to the hand line up to 20 fathoms, after which every 10th fathom is marked by an additional knot, and every intervening 5th fathom by a single knot. Thus:—

There	is 1 knot at 25 fathoms.	There	are 3 knots at 30 fathoms.
"	is 1 knot at 35 "	"	are 4 knots at 40 "
"	is 1 knot at 45 "	"	are 5 knots at 50 "

and so on up to 100 or 120 fathoms. The 100 fathoms is marked by leather with 2 holes, or with a piece of rag, after which the knots are repeated

The deep-sea lead weighs from 28 to 30 lbs.

Both leads have cavities in their heels to admit of their being armed. The deep-sea lead should always be armed before heaving, in order that the nature of the bottom may be ascertained as well as the depth for comparison with the chart.

TO TAKE A CAST OF THE DEEP SEA LEAD

The Ship's Way through the water is stopped, the lead is carried forward, the line is passed forward on the weather side outside of everything and made fast to the lead.

The Hands are stationed along the weather rail with a few bights of the line in their hands When ready, the lead is dropped into the sea and as the line is carried down by it each man in turn calls out "watch there, watch," as the line leaves his hand.

The Officer in charge has the line in his hand at about the expected depth, and when the strain comes off the lines he gives the lead a dump or two on the bottom to get a good up and down cast. He then estimates the depth of water by the mark on the line, making due allowance for the height of the ship's rail above the sea level.

The line is then wound up on the reel as it is hauled in to be ready for another cast should one be required. The tallow arming on the heel of the lead is cut off and the nature of the bottom, be it sand (s), shell (sh), mud (m), gravel (g), stone (st), coral (crl) is compared with that given on the chart against the depth obtained. The depth of water and the nature of the sea bottom when taken into conjunction with the estimated position of the ship give the navigator some further assurance as to his actual position. Fishermen in the North Sea grope their way about and recognise particular fishing banks in this way.

The cast being satisfactory the ship gets under way again.

PATENT SEA SOUNDING MACHINES.

Most patent sounding machines are based on the fact that the pressure of the water on an immersed body increases with the depth to which it is immersed.

Boyle and Marriotte's Law is made use of in some of them. Applied to the sounding machine it may be stated briefly as follows:—**The**

volume of any given mass of air, or other gas, decreases in the same proportion as the pressure upon it increases.

A glass tube, protected by a brass or copper case, is lowered to the bottom with the aid of a sinker This tube contains air, and the inside of it is coated with a chemical preparation called chromate of silver. The tube is open at the bottom, and water is forced into it according to the pressure to which it is subjected. The salt water discolours the

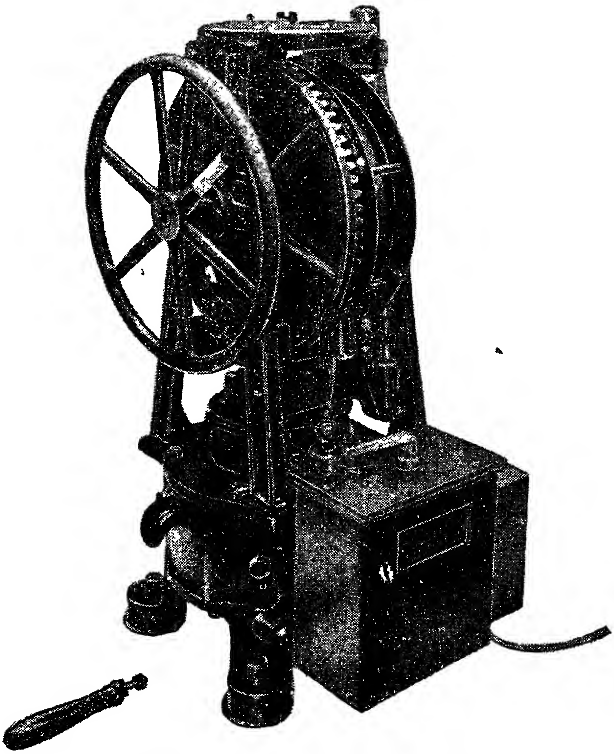


Fig. 3.—A Kelvin Sounding Machine, Electric Control.

chemical, turning it into chloride of silver, thus showing how far the water has entered the tube. By comparing this with a scale, which is supplied with the sounding machine, the depth to which the tube has descended is read directly from the scale.

In another make, the water which enters the tube is retained, and according to the water drawn up in the tube so the depth which the tube has reached can be read from a scale which is supplied with it.

Another one, made of brass or copper, contains a spring, against which a piston is forced up by the pressure of the water. The depth is indicated by a pointer, which shows how far up the tube the piston has been, and the corresponding number of fathoms is read off the tube itself.

Most of the foregoing sounders can be used while the ship is going at full speed, but the makers of some of them advise slowing down to 8 or 10 knots.

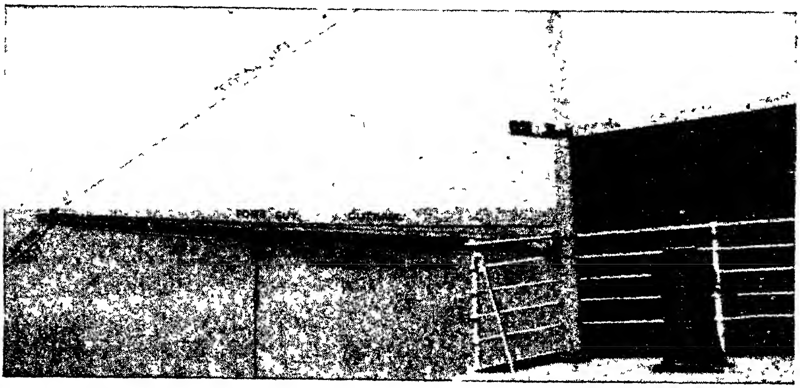


Fig. 4.—Side Boom to Enable Soundings to be made from the Bridge.

Some winches are fitted with a dial which registers the amount of wire run out. A Table is provided which, when entered with the two known factors, viz., speed of ship as the base line of a right-angled plane triangle, and the wire run out as the hypotenuse, gives the depth of water in fathoms (approximately) as the perpendicular side. It is assumed that the sinker drops vertically to the bottom at the rate of about 15 feet per second.

HOW TO TAKE A CAST WITH A PATENT SOUNDING MACHINE.

Pass the sounding wire through the pulley on the rail at the stern of the ship, or on the side-boom shackle the wire on to the short piece of rope spliced into the lead and to which is attached the brass container. Put the glass tube into the container open end downwards. When ready, hang the lead over the stern, release the brake on the winch and the wire will run out free wheel. Keep feeling the wire with the brass feeler

provided for the purpose, and when the wire slackens up the lead will have just touched bottom Apply the brake gradually and heave in. Take the glass tube out of the container, taking care to keep it vertical, and apply the tube to the wooden graduated scale from which the depth in fathoms is read off. Lift the lead on board and examine the arming and leave everything clear for taking the next sounding.

THE ECHO SOUNDING MACHINE

The Echo Sounding Machine is being rapidly developed and it is assuredly a most effective aid to navigation The principle is simple and depends upon the fact that sound travels in water at a known speed and is reflected from the seabed in the same way that a sound wave in air is reflected from hills and cliffs.

ECHO SOUNDING MACHINE—ADMIRALTY PATTERN.

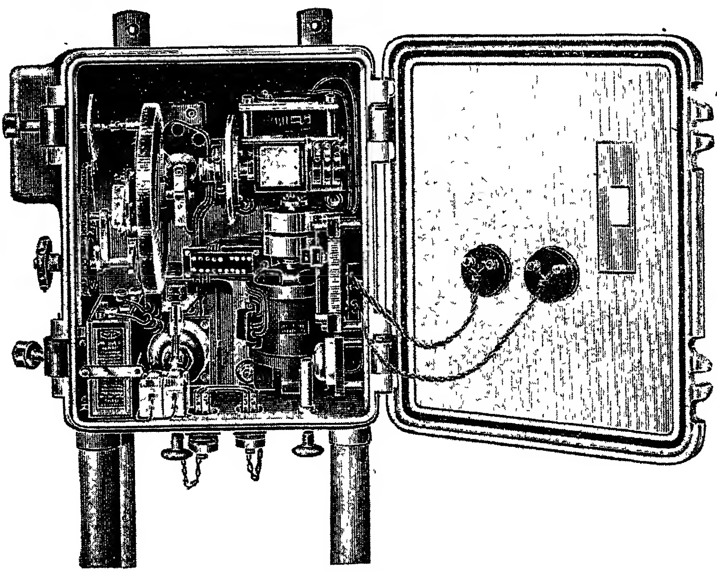


Fig. 5.—Recording Apparatus.

The application of the principle in practice calls for ingenuity and specialised scientific knowledge in adapting electrical apparatus to recording the very small interval of time taken by a sound wave to travel down to the bottom of the sea and back again to the ship.

The apparatus consists of (1) a transmitter fitted inboard to the bottom of the ship to produce a sound wave under water; (2) a sensitive receiver of the echo reflected from the seabed known as the hydrophone; (3) recording gear for measuring the interval of time between the sound impulse and the sound echo. The transmitter and receiver are fitted on opposite sides of the ship as indicated in Figure 6 and the recording apparatus is placed on the bridge.

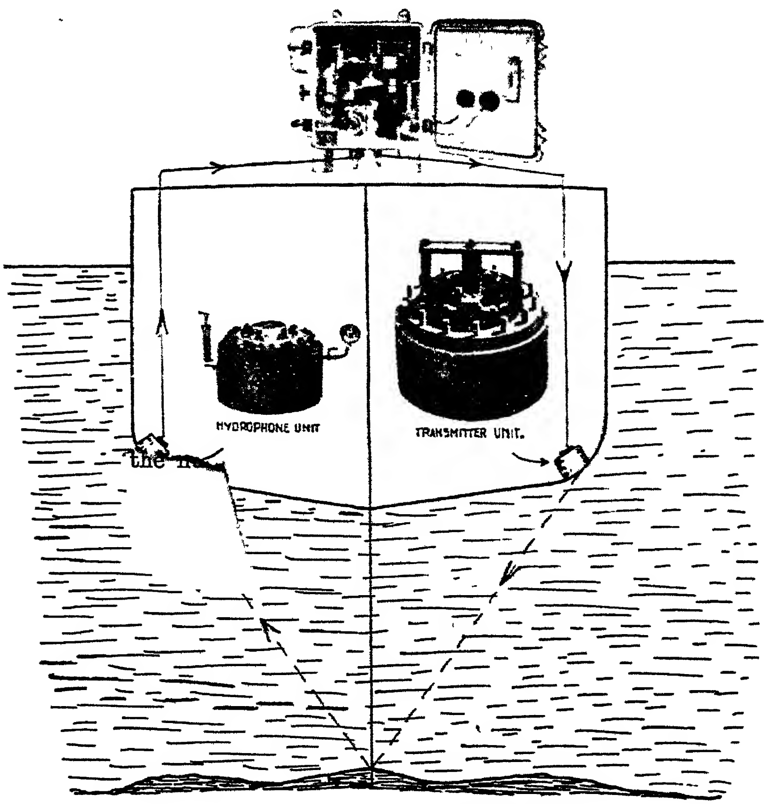


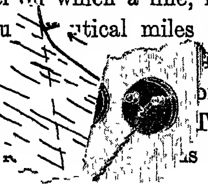
Fig. 6.—The Path of the Sound.

The method of taking soundings is simple. The observer pulls down the writing table in front of the instrument, thus exposing to view the depth scale which he turns back till brought up by the stop at the lower end of the scale. He now switches on the gear by inserting

the main switch, situated on the underside of the receiving box and puts on the telephone receivers. A **faint** tapping will be heard but this is disregarded. He now works his hand wheel, moving up a foot at a time, until the tapping **suddenly** becomes louder, and reads off the depth directly from the scale. The time taken by the sound wave to travel to the bottom and back is converted by the recording apparatus into echo feet or fathoms. Figure 5 shows the recording apparatus with the door open, and Figure 6 gives a diagrammatic idea of the same apparatus in a convenient place on the bridge, with the cable leading down to the transmitter where a hammer is operated by a solenoid; the sound wave thus set in motion travels to the bottom and up again, the sound being picked up by the hydrophone and passed on through the return cable to the head telephone of the observer.

An additional instrument is now being attached to the apparatus, which produces automatically a trace of the contour of the seabed and thus exhibits a continuous picture of what the vessel is passing over and relieves the officer of the duty of listening-in.

THE COMMON LOG



The common log consisted of a reel on which a line, marked off into equal lengths to represent miniatu[illegible]utical miles and called "knots," was wound, a log chip and a [illegible]. The log chip was a triangular shaped piece of [illegible] one edge so that it would float vertical, apex upwar[illegible] The log line was secured to the three corners of the [illegible]s of a three-legged bridle.

The operation of "heaving" the log was as follows. One man held the reel, another man the sandglass and the officer threw the log chip into the water and paid out the line. The log chip remained stationary in the water astern and the ship sailed away from it. When a certain length of line, called "stray line" to allow the log chip to get clear of the eddy water in the wake, passed over the rail the officer called out "turn" and the man turned the glass. As soon as the glass ran out he called out "stop"; the officer held the line and noted the nearest mark and so got the speed the ship was going at the time.

The Principle in dividing off the log line was to make the distance between the knots on the line bear the same proportion to a nautical mile (6080 feet) as the seconds of the glass bore to the seconds in an **hour** (3600).

Example.—Required the length of the knot on the log line for a 14 second glass.

$$\frac{\text{Knot}}{\text{Mile}} = \frac{\text{the glass}}{\text{an hour}} \text{ or } \frac{x}{6080} = \frac{14}{3600}$$

$$\therefore x \text{ knots} = \frac{6080 \times 14}{3600} = 23 \text{ ft. } 7 \text{ ins.}$$

About 15 fathoms from the end of the line a piece of white rag was tucked to indicate the beginning of the marked line, and to know in heaving when the glass was to be turned. The line was then divided off into equal lengths of 23 ft. 7 ins. and marked as follows.

To indicate a speed of	1 knot	1 small strip of leather.
,, ,,	2 knots	2 small strips of leather.
,, ,,	3 ,,	3 small strips of leather.
,, ,,	4 ,,	a piece of cord with 2 knots in it.
,, ,,	5 ,,	a piece of cord with a single knot.
,, ,,	6 ,,	a piece of cord with 3 knots in it.
,, ,,	7 ,,	a piece of cord with a single knot.
,, ,,	8 ,,	a piece of cord with 4 knots in it.

and so on.

A short method of finding the approximate length of a knot was to add a cypher to the number of seconds run by the glass, and divide by 6. This gave the number of feet, the remainder multiplied by 2 gave the inches.

$$\begin{array}{r} 6)140 \\ \hline 23 \text{ ft. } 4 \text{ ins.} \end{array}$$

The common log is no longer used at sea and we have referred to it in the past tense, but reference to it is still of historical interest owing to the fact that the word "knot," which is a "unit of speed" and not of distance, is derived from the marks on the hand log line. When, say, 3 knots on the line had run out the seaman knew that the ship's speed through the water was 6 nautical miles per hour, and if 4 knots ran out that she was going 8 nautical m.p.h., hence the query "how many knots is she going?"

THE PATENT LOG.

There are many different kinds of patent logs now in use, and all candidates should have some practical knowledge of the use and care of them.

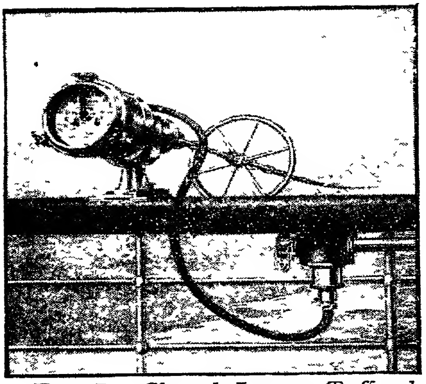


Fig. 7.—Cherub Log on Taffrail

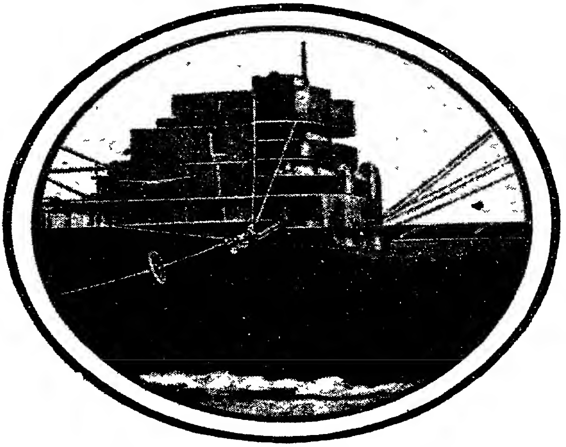


Fig. 8.—Cherub on Side Boom.

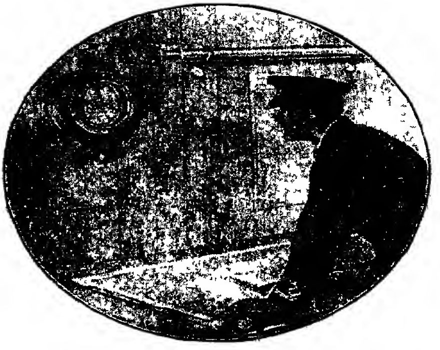


Fig. 9.—Recorder in Chartroom.

Walker's Patent "Cherub" or "Neptune" Taffrail Log is one greatly used nowadays, and most candidates will have had more or less experience in its working. It consists of a cylindrical brass case with a dial, the case containing the registering machinery.

The dial is marked round its edges from 0 to 100, these figures representing miles. A brass hand points to the number of miles run. There is also a smaller hand, like the seconds hand of a watch, which indicates the quarter miles. A bell within the brass case is struck as each sixth part of a mile is recorded, that is, the bell is struck six times during a run of one mile.

In the latest type of "Cherub" log the small hand indicates tenths of miles instead of quarters, and the bell is not fitted.

A rotator is towed by means of a patent log line. This revolves according to the speed of the ship, and works the mechanism in the brass case, the distance covered being read from the dial. A "governor" is attached to the line just abaft the rail; this helps to make the log work at a uniform speed.

The figures show an electric "Cherub" log fitted to the taffrail and connected up to a repeater log in the chartroom. A common practice is to tow the log from a boom amidships as shown in Figure 8, the speed indicator being in the chartroom or on the bridge.

1. Having "streamed the log," what attention will you give it while in use?

See that the line is clear, the governor is acting properly, and that there is nothing foul of the rotator. Take every opportunity of testing the accuracy of its readings, not forgetting that it indicates the distance travelled through the water, not the distance made good over the ground. Give the mechanism a drop or two of good oil occasionally. Take care to haul it in before stopping, or when likely to have to go astern on the engines.

2. Does the dial indicate the speed at which the ship is travelling at the time you look at it, or does it only record the number of miles run?

It only records the number of miles and quarters or tenths of a mile which the ship has run.

3. What length of log line would you pay out?

The length of line will depend on the freeboard of the vessel and her speed, more line being paid out when in ballast than when loaded so that the rotator may be kept well submerged and clear of eddy water in the wake. The usual length is 40 fathoms at 10 knots, but for small vessels and slower speeds shorter lengths can be used.

The accuracy of a log may be tested by checking it against the known distance steamed between two fixed points, or by trials on a measured mile, making due allowance for the effect of tide, if any. On measured mile trials the mean of the speeds, not of the times, is used. If the log registers too low, lengthening the line usually increases the log registration.

4. When a patent log line is hauled in, how do you get the turns out before drying it and stowing it away?

By paying it out over one quarter as it is hauled in on the other. When I haul it in from the rotator end, it comes up clear of turns. Where a clear run of deck is available, by hooking the line on to a swivel and running along the deck with it, it can be hauled in without any turns getting in it.

5. What do you do with the part which you unship from the rail before stowing it away?

Clean it well, both inside and outside. Work some kerosene through it, and, when you have got it thoroughly clean, some olive oil will keep it in good condition till you want to use it again. The rotator should also be cleaned and oiled.

Electrical Ship Logs have been devised to give a continuous record of the speed through the water and the total distance run by measuring, either in pressure units or in units of rotation, the flow of the water passing the ship.

The Chernikeeff Log is manufactured by the Electric Submerged Log Company, London. It records the distance run through the water at any speed from practically zero up to 40 knots.

The apparatus consists of a distance recorder (2) fitted in the chart-room, which registers every 20th part of a mile, the dial being calibrated up to 10,000 miles. A speed table is fitted below the speed indicator dial and an electric flash lamp below the table. If the time is taken by a stop watch between the flashes, the speed can be read direct from the

speed table. A 6-volt dry battery (3) provides the current necessary to operate the distance recorder.

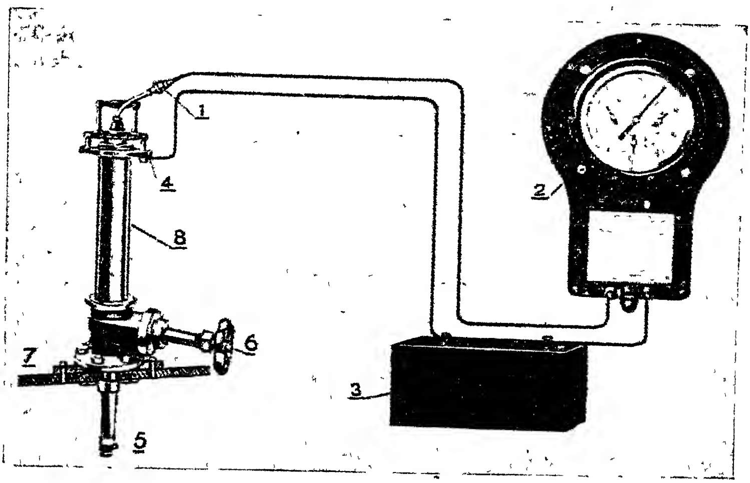


Fig. 10.—Chernikeeff Electric Log.

The essential element is an impeller (5) fitted in a horizontal tube at the end of a vertical rod which protrudes 10 to 15 inches outside the bottom of the vessel. This vertical rod passes through a tube (8), which is flanged and riveted to the shell plating at (7), a sluice valve (6) ensures watertightness when the impeller rod is drawn inboard by means of its handle at the top end.

The impeller is rotated by the flow of water passing the ship, the pitch being such that it makes one revolution for every 1·35 feet of distance run. The gearing and electrical connections are so arranged that a contact is made at every 45th revolution of the impeller, that is, on the completion of every 60·8 feet of distance run. The contact energises the coil in the distance recorder and each impulse allows the indicator to move round one division on the dial, each division representing 60·8 feet of travel or one-hundredth of a nautical mile.

THE SPEED OF THE PROPELLER.

An approximation of the speed and distance sailed may be computed from the revolutions of the ship's propeller, the uncertain factor in the calculation being the "slip."

The **Pitch** of the screw is the distance it would move the ship ahead in one revolution, supposing there is no slip, or supposing it to revolve in a solid instead of in water.

The **Slip** is the difference between the actual speed of the ship and the speed of the propeller or engine speed. It is due to the yielding of the water to the pressure exerted on it by the screw as it forces the ship ahead. The slip is increased when the wind and sea are ahead, also when the ship's bottom is foul and her progress through the water retarded.

The **Engine Speed** is the rate at which the propeller would drive the ship if there was no slip.

Example.—Required the speed of a ship, the pitch of propeller being 18 feet, and making 70 revolutions per minute, no slip.

Speed = pitch × revs. × 60 minutes ÷ ft. in nautical mile

Speed = 18 ft. × 70 × 60 ÷ 6080 = 12·43 knots

Example.—A propeller has a pitch of 20 feet and makes 65 revs. per minute. The log registers 10·5 miles in one hour, what is the slip?

Engine speed = pitch × revs. × 60 ÷ 6080

" = 20 ft. × 65 × 60 ÷ 6080 = 12·8 knots

Actual slip = engine speed − speed of ship = 12·8 − 10·5 = 2·3 miles per hour

Slip is usually expressed as a percentage.

Slip per cent. = actual slip × 100 ÷ engine speed

" = 2·3 × 100 ÷ 12·8 = 18 per cent

FUEL CONSUMPTION AND SPEED.

Equations connecting coal consumption and speed are merely approximate and have been deduced from experiment and experience as so much depends upon the quality of the coal, the design and efficiency of engines and boilers, the trim of the ship and the state of the weather. Bad steering reduces the speed.

The consumption of coal or oil varies approximately as the "cube of the speed" and also as the "speed squared multiplied by the distance" for moderate speeds up to about 14 knots, after which the ratio of consumption to speed increases very steeply.

$$\text{I.}\quad \frac{\text{new consumption}}{\text{old consumption}} = \frac{\text{new speed}^3}{\text{old speed}^3} = \frac{\text{new displacement}^{\frac{2}{3}}}{\text{old displacement}^{\frac{2}{3}}}$$

$$\text{II.}\quad \frac{\text{new consumption}}{\text{old consumption}} = \frac{\text{new speed}^2 \times \text{new distance}}{\text{old speed}^2 \times \text{old distance}}$$

Example.—A vessel's consumption of coal is 30 tons per day at 12 knots, required her consumption at a reduced speed of 10 knots.

$$\frac{\text{new } C}{\text{old } C} = \frac{\text{new speed}^3}{\text{old speed}^3} \quad \therefore \frac{C}{30} = \frac{10^3}{12^3}$$

$$C = \frac{30 \times 10 \times 10 \times 10}{12 \times 12 \times 12} = 17{\cdot}3 \text{ tons}$$

Example—In bad weather a vessel makes 10 knots for 4 days of 24 hours each on 25 tons of coal per day and finds she has 1000 miles to go and only 80 tons of coal left. Find the reduced speed to enable her to reach port under the same weather conditions.

Write down the equation, fill in the quantities given in the question and solve for speed.

$$\frac{\text{new } C}{\text{old } C} = \frac{\text{new speed}^2 \times \text{new distance}}{\text{old speed}^2 \times \text{old distance}}$$

$$\frac{8\not{0} \text{ tons}}{100 \text{ tons}} = \frac{\text{speed}^2 \times 1\not{0}\not{0}\not{0} \text{ miles}}{1\not{0} \times 1\not{0} \times 96\not{0} \text{ miles}} \therefore \text{speed}^2 = 8 \times 96 \div 10 = 77$$

Speed $= \sqrt{77} = 8{\cdot}8$ knots. Reduce to 8·5 knots until the weather conditions for steaming improve.

Example.—The average speed is 12 knots on 40 tons of coal per day. After 10 days' steaming there is 350 tons of coal left and 3000 miles to go. Required the reduced speed to reach port.

Ans.—11 knots.

THE MARINE BAROMETER—CONSTRUCTION AND PRINCIPLE.

The barometer consists of a glass tube about 33 inches in length, closed at one end and filled with mercury. The tube is then inverted and its lower end immersed in a cistern containing mercury. The column of mercury remains stationary in the tube at a height corresponding to the pressure exerted by the atmosphere on the surface of the mercury in the cistern. The column lengthens when the pressure is increased and shortens when the pressure is diminished, thus the weight of the column exactly balances the pressure of the atmosphere. The height of the top of the column above the surface of the mercury in the cistern is measured by means of scales graduated in inches or millibars or both. The space between the mercury and the top of the tube is called the Torricellian vacuum.

An analogy exists between the action of a pump and the action of a

THE MARINE BAROMETER.

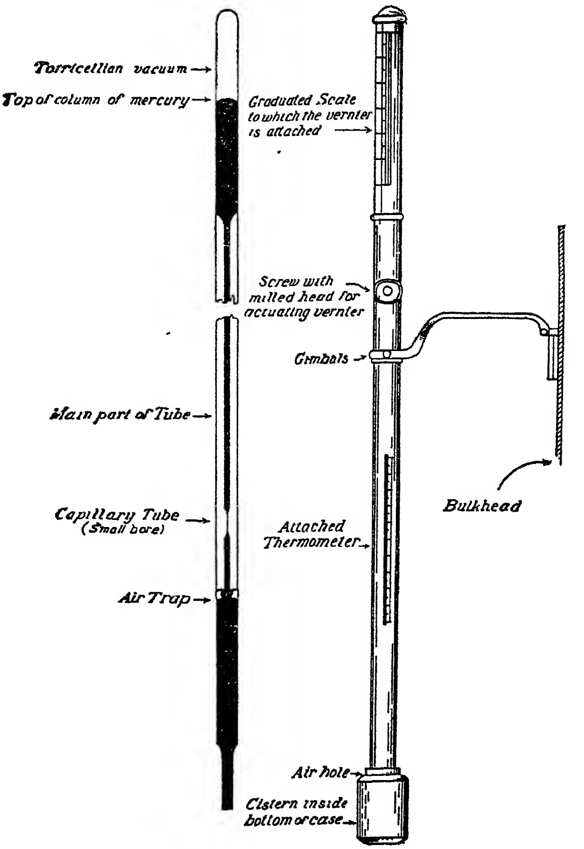


Fig 11.

The barometer is an instrument for measuring variations in the weight or pressure of the atmosphere.

The most important part of it is a glass tube containing mercury. This tube is airtight at the top and open at the bottom. It is fitted in a case with its open end immersed in a cistern also containing mercury. The pressure of the atmosphere on the surface of the mercury in the cistern maintains the column of mercury in the tube at a height which corresponds to that pressure. Readings are obtained by means of a graduated scale and vernier.

The left-hand drawing represents the glass tube taken out of its case so that the different parts of it can be seen. The other one shows the complete instrument suspended from a bulkhead by means of an arm and bracket.

barometer. When the pump is at rest the atmospheric pressure in the chamber is equal to the pressure on the surface of the water in the well. When the pump is worked, a partial vacuum is created in the chamber, thus diminishing the pressure, so that the relatively greater pressure exerted on the surface of the water in the well raises the water into the pump chamber.

In like manner, the pressure having been removed from the inside of the tube of the barometer by expelling the air, the pressure of the atmosphere on the surface of the mercury in the cistern forces the mercury up the tube, until the weight of the column is equal to that pressure.

A water barometer would require a tube about 33 feet in length, but mercury, being 13½ times heavier than water, only requires a tube about 32 inches in length.

Pumping is the name given to the rising and falling of the mercury caused by the heaving of the ship at sea, or the rocking of the instrument. Pumping is reduced by contracting the bore of the tube and also by slinging the barometer in gimbals.

Certain precautions have to be observed when taking down a barometer and packing it for transport to protect it from damage.

Unship it from the bracket and handle it carefully. The instrument should be brought into a horizontal position very gradually in order to allow the mercury to flow gently to the top of the tube. Put the barometer in its box and use soft packing, avoid jars and concussion, and carry the box horizontally with cistern end tilted up slightly. If sending by post or rail, put the label on the end next to the cistern, and mark it boldly "scientific instruments—glass—fragile—keep flat or this end up."

If a mercurial barometer were brought quickly from an upright to a horizontal position the weight of the mercury would probably break the glass as there is no air at the top of the tube to act as a cushion.

A Millibar is the thousandth part of a "Bar," which is the unit adopted by meteorologists to express the average pressure of the atmosphere at sea level and is approximately 14½ lbs. per square inch=1000 millibars=29·5 inches of mercury.

The Vernier is a sliding scale by which more accurate readings of a fixed scale may be obtained. The principle of its construction is, that a given length of vernier, equal to a certain number of divisions of the fixed scale, is divided into one more or one less than that number of divisions. The inch vernier of the marine barometer is usually equal

in length to 9 divisions of the fixed scale and divided into 10 equal parts, the degree of accuracy thus obtained being ·005 of an inch.

The millibar vernier is equal to 39 divisions of the fixed scale, but instead of being divided into 40 parts, the vernier is divided into 10 equal parts, thus giving a wider spacing of the divisions making it easier to read without loss of accuracy, the nearest reading obtainable being one-tenth of a millibar.

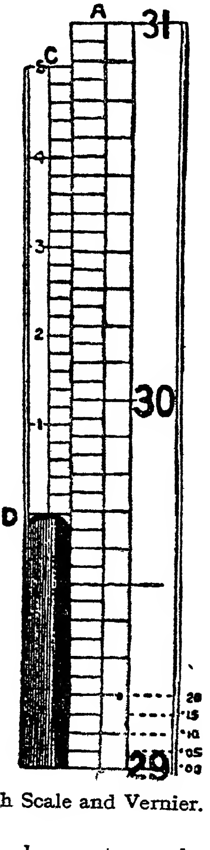


Fig. 12.—Barometer Inch Scale and Vernier. The Reading is 29·684.

The figure illustrates a barometer scale and vernier graduated in inches. *AB* is the fixed scale, *CD* the sliding vernier, *D* is the top of the mercury column. The reading is 29·684 arrived at as follows:

The point *D* lies between 29·650 and 29·700, the lower reading is noted, 29·65 and the additional part is got from the vernier. The

spacing on the fixed scale is ·05 of an inch, and this is divided into five equal parts by means of the enlarged divisions numbered 1, 2, 3, 4, 5 on the vernier; these parts, however, are really ·01, ·02, ·03, ·04, ·05, the ·0 being left out for convenience. Run the eye up the vernier until one of its divisions is exactly coincident with any division of the fixed scale. It is the second one above 3 which is ·034 to add to 29·650 making the reading 29·684. The short divisions between the numbered ones on the vernier are in succession ·002, ·004, ·006, ·008 of an inch.

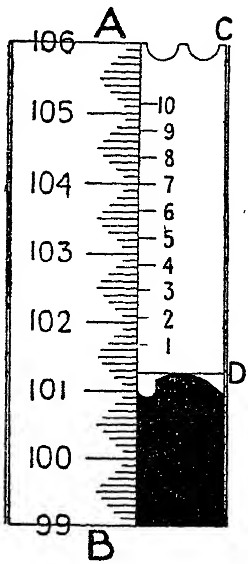


Fig. 13.—Millibar Scale and Vernier. The Reading is 1012·7 mb.

Figure 13 shows part of a millibar scale. *AB* is the fixed scale from 990 mb., to 1060 mb. *CD* is the sliding vernier, *D* is the top of the mercury column. The reading is 1012·7 millibars. The millibars are read from the *AB* scale and the decimal from the *CD* scale.

Instrumental Corrections for Latitude, temperature and height above sea level are necessary in order to reduce the observation to a common standard for the purpose of comparison with the readings got from other barometers.

The standard Latitude is 45°, this correction is necessary because the force of gravity is greater at the poles than at the equator, due to the polar diameter of the earth being shorter than the equatorial diameter.

The standard height is sea level, the correction being about one-tenth of an inch for every hundred feet, and is due to the atmospheric pressure decreasing with the height.

The standard temperature is 32° Fahr; this correction is necessary because the column of mercury lengthens and shortens with heat and cold.

The value of these several corrections may be found in the *Barometer Manual.*

Errors of Capillarity and Capacity.—Capillarity is due to the surface tension of the mercury and the frictional resistance between the mercury and the glass tube. It depresses the level of the mercury.

Capacity is due to the changes in the level of the mercury in the cistern as it rises and falls in the tube.

The scale of marine barometers is graduated to obviate the necessity of applying these two corrections, the mercury inches being shorter than lineal inches.

An Aneroid Barometer consists of a circular metallic chamber partially exhausted of air and hermetically sealed. Variations in the pressure of the atmosphere produce changes in the volume of the chamber, and by an arrangement of levers and springs the motion thus imparted to the chamber is communicated to a hand which indicates the prevailing pressure.

It is not so reliable as the mercurial barometer, with which it should be frequently compared, nor is it possible to find with sufficient accuracy for scientific purposes the index error of the aneroid.

Aneroid readings require correction for height above sea level and index error, but not for temperature or latitude.

An aneroid is popular on board ship because it is very handy and also more sensitive to small changes of pressure than the mercury barometer. Space often being an important consideration, it can be hung in positions which would be impossible for a mercury barometer. Having no vernier to adjust, readings are quickly and easily obtained. Being used principally to indicate *changes* of pressure as an aid to forecasting the weather, it is not customary to apply any corrections to its reading.

A Barograph is a self-recording aneroid. It consists of a series of vacuum metal boxes with elastic lids. The volume of the boxes changes with every variation of pressure in the same way as in the aneroid barometer. The expansion and contraction thus caused are communicated through a lever to a pen, which marks an ink trace on a paper. This paper is wound round a drum, which is rotated on a vertical axis

by means of clock work, making a complete revolution in seven da
The vertical lines printed on the barograph chart represent time, a
the horizontal lines either inches or millibars. The pen moves up a
down in response to changes of pressure. and the revolving dr
imparts a horizontal motion to the paper which slips round under the pe

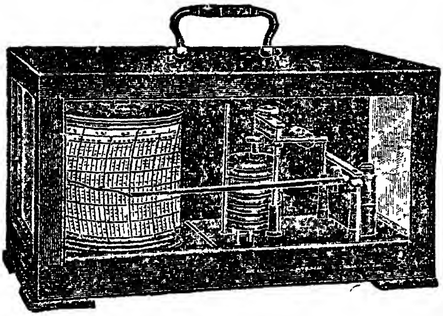


Fig 14.—A Barograph

The chief advantage lies in the fact that a continuous record c
changes in pressure is presented in a graphic form, by means of whic
the history of the barometrical changes may be read at a glance, eve
slight fluctuations of pressure due to passing squalls being recorded.

Barograph readings are subject to the same corrections as th
aneroid, in addition to regulating its time at sea. The drum rotates a
a uniform rate, while the ship time changes as she sails East or West
the drum should therefore be set to G.M.T. and the ship's Longitud
noted on the barograph chart.

THE THERMOMETER.

Construction and Principle.—It consists of a glass tube of very small bore, having a bulb attached to one end, sealed at the other, and partially filled with mercury, or with spirits of wine if the instrument is required for very low temperatures.

Bodies expand with heat and contract with cold, and as mercury expands to a greater degree than glass we find the thin thread of mercury rising and falling in the tube as the temperature increases and decreases respectively.

The two fixed points of the scales used in making thermometers are the freezing point and boiling point of distilled water, when the barometrical pressure is 30·0 inch

The space between these two points is divided into equal parts cal degrees; the following systems of graduating have been adopted.

	Fahrenheit	Centigrade	Absolute.	Réaumu
Boiling point - -	212°	100°	373°A	80°
Freezing point - -	32°	0°	273°A	0°

The spacing of the degrees in the Absolute scale is the same as in the Centigrade, but there are no minus readings with the former.

The real reason why Fahrenheit fixed the zero of his scale as 32 degrees below the freezing point of water seems to be lost in the mists of obscurity, but the zero of the Absolute scale is based on the doctrine that gases contract on being cooled, their volume being diminished with loss of temperature. The zero represents the temperature at which a gas would have no volume, it would then cease to exert pressure, or be capable of developing energy.

The figure represents a portion of a thermometer showing the Absolute scale to the left side of the thread of mercury and the Fahrenheit scale to the right. The space between freezing point and boiling point is divided into 100 parts, 0 to 100, in the Centigrade scale; and 180 parts, 32 to 212, in the Fahrenheit scale, so that 100° C. is equal to 180° F. It is sometimes required to convert one reading into the other which may be done as follows by assuming that Fahrenheit called the freezing temperature of water 0 as he might have done.

Example.—Convert 310° Abs. into the corresponding Fahr. reading.

$$310 \text{ Absolute} - 273 = 37 \text{ Centigrade}$$

$$\frac{\text{Fahr. reading}}{\text{Fahr. range}} = \frac{\text{Cent. reading}}{\text{Cent. range}}$$

$$\frac{x}{180} = \frac{37}{100} \quad \therefore x = \frac{37 \times 180}{100} = \frac{333}{5}$$

$$= 66{\cdot}6 + 32 = 98{\cdot}6 \textit{ Ans.}$$

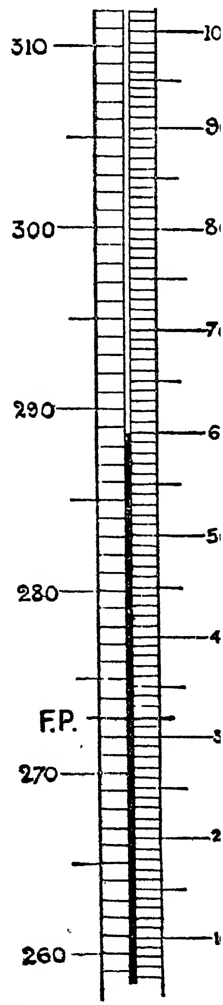


Fig 15—Fahrenheit a Absolute Scales.

We add 32° to get the Fahr. reading, 98·6, because in the calcuiatio we assumed freezing point to be 0 instead of 32°.

Example.—Convert 60° Fahr. into the corresponding Absolute scal reading.

Assume freezing point Fahr. to be zero then 60—32=28.

$$\frac{\text{Cent. reading}}{\text{Cent. range}} = \frac{\text{Fahr. reading} - 32}{\text{Fahr. range}}$$

$$\frac{x}{100} = \frac{28}{180} \therefore x = \frac{28 \times 100}{180} = \frac{140}{9} = 15{\cdot}5 \text{ C}$$

$$+273{\cdot}0$$

Ans. $\underline{288{\cdot}5}$ Abs.

Check those answers by referring to Figure 15.

THE MAXIMUM THERMOMETER.

The maximum thermometer is designed to record the highes temperature experienced during a given period. The tube is reduce in bore about an inch from the bulb. The thermometer is hung nearl

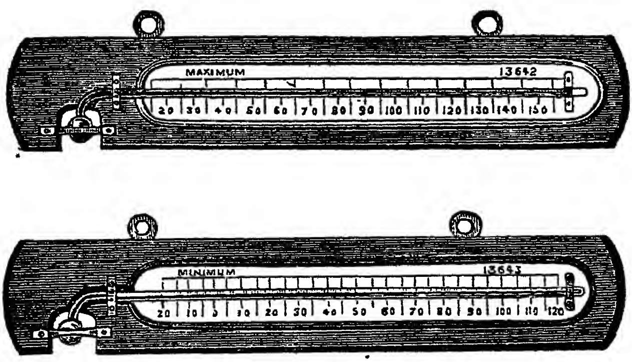


Fig. 16.

horizontally with the bulb end slightly lower than the other. A the temperature rises the mercury expands and is forced past the constriction, but, when a subsequent fall of temperature causes a contraction of the mercury, the thread breaks at the constriction sc that its upper end remains in position and registers the highest tempera

ture reached. To reset the thermometer, hold it vertically, bulb down shake gently and the thread of mercury will reunite with the mercury in the bulb.

THE MINIMUM THERMOMETER.

The minimum thermometer records the lowest reading experienced in a given interval The most common type is a spirit thermometer having a small index immersed in the spirit in the stem. It is also

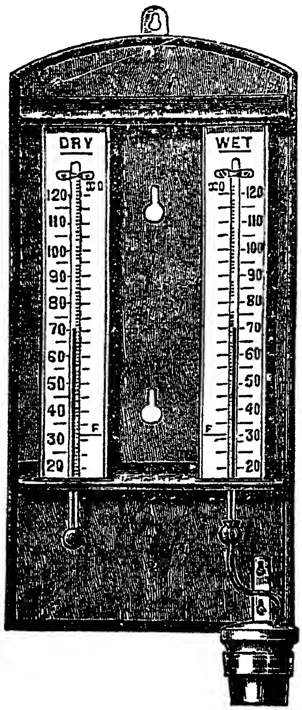


Fig. 17.—Hygrometer.

hung horizontally. As the temperature falls the index is carried towards the bulb by the spirit, but if the spirit subsequently expands, in consequence of a rise of temperature, it flows past the index, which is left in position to indicate the lowest temperature reached. To reset this thermometer, hold it vertically, bulb up, tap it gently and the index will find its way back to the end of the thread of spirit. (Fig. 16).

The Thermograph is a self-recording thermometer, which gives a

continuous record of temperature. The thermometer consists of a slightly curved metal tube filled with spirit, one end of the tube being fixed rigidly to the instrument, and the other end attached to the system of levers which actuates the recording pen.

The great advantage of the thermograph, especially if studied in connection with a barograph, is to demonstrate the close relationship which exists between the fluctuations of temperature and pressure.

Thermographs must be exposed out of doors and consequently the bearings require to be frequently oiled and examined. The instrument takes an appreciable time to alter in temperature, so it is apt to be sluggish when the changes of temperature are rapid.

MASON'S HYGROMETER

It consists of two ordinary thermometers placed side by side. One, called the wet bulb, has a piece of cambric tied to the bulb, and a few strands of cotton wick fastened to the cambric with their lower ends dipping into a cup of water. The cambric is thus kept moist. The thermometers should be mounted in an open screen through which the air passes freely, and away from the effects of heated currents of air from cabins, etc.

Care should be taken to keep the cambric and wick clean, and the cup replenished with a supply of fresh water. Should the cambric and wick get wet with salt spray, they should be cleaned in fresh water, and care should be taken that no water is adhering to the dry bulb when the readings are noted.

The hygrometer measures the humidity of the air. When the air is dry, evaporation takes place and the water dries off the cambric, thus reducing the temperature of the wet bulb thermometer; when the air is moist there is less evaporation so that the difference between the wet and dry bulb readings is correspondingly less.

Consequently, in damp weather or when the air is saturated, there is little or no difference in the readings, but in dry weather at sea the wet bulb may be as much as 10° lower than the dry bulb (Fig. 17).

A RAIN GAUGE

This instrument is not usually included in the weather recording apparatus supplied to ships, but if it were carried it would be hoisted to a suitable height above the deck where it would be free from the sheltering effects of deckhouses, etc., also from spray.

It consists of an open mouthed canister 5 inches in diameter as in the figure. The raindrops fall into the can and pass through the funnel into the jug. The rain water is poured from the jug into the measuring

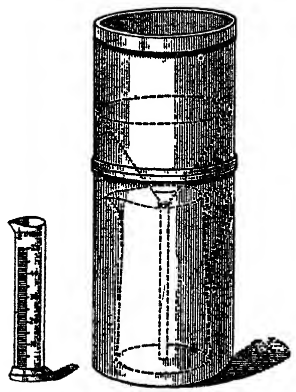


Fig 18.—Rain Gauge.

glass, which is scaled off into hundredths of an inch of rainfall. One inch of rain caught in the rain gauge represents a rainfall of 101 tons per acre, or its equivalent volume of 3630 cubic feet of water.

RADIO DIRECTION FINDER

Directional wireless as an aid to navigation is a usual part of the equipment of a well found ship. Figure 19 illustrates the apparatus supplied by the Radio Communication Company, London. The frame. or loop aerial on the bridge is rotated by means of the handwheel fitted to the lower end of the vertical spindle, which extends down from the aerial through the deck to the chartroom below. The frame aerial when rotated picks up the wireless wave, the signal strength reaching its loudest when the plane of the frame aerial is parallel to the incoming signal, that is, when it is edge-on to the direction of the station from whence it is being transmitted.

The position of maximum strength is not sharply defined, but on rotating the frame the signal strength gradually drops to inaudibility when the frame is facing the direction of the station. A well defined "silence arc" of a few degrees on each side of the required direction is established and by rotating the frame either way the signal again rises to audibility. It is then a simple matter to observe by the

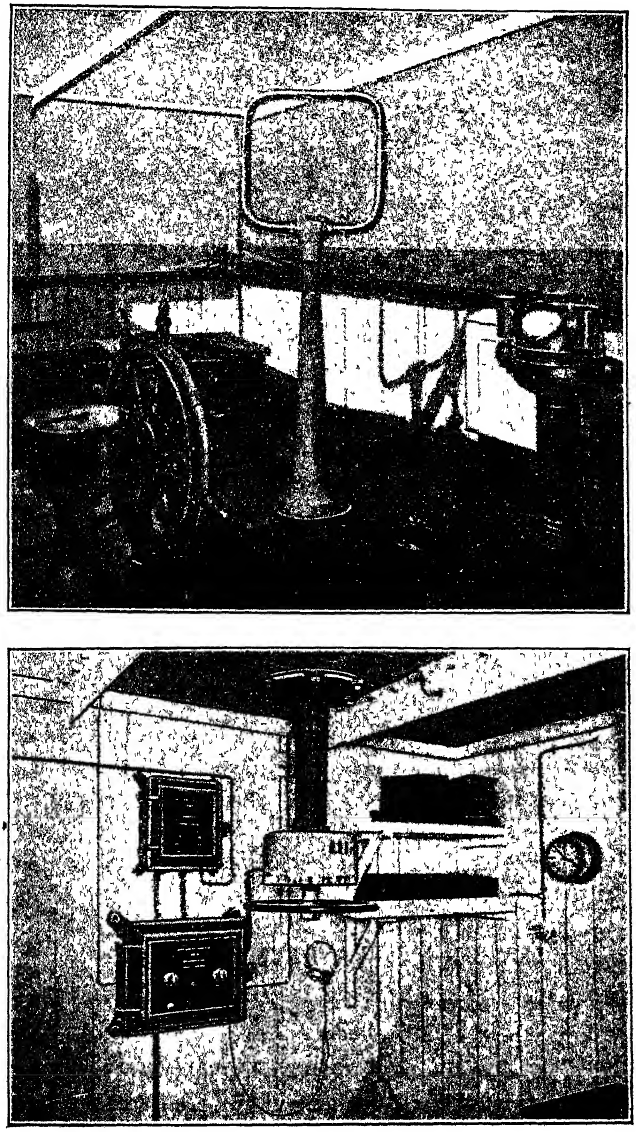


Fig. 19.—Radio Direction Finder.

Pillar of aerial through bridge deck into chartroom and operated by hand-wheel on its lower end.

pointer on the scale of degrees the two points limiting the arc of silence and the mid-point between which gives the required direction but, in the first instance, the direction is relative to the ship's head only. The actual direction of the ship's head by compass should be taken at the same time as the wireless observation to enable the true bearing of the distant station to be obtained.

Example.—The radio direction finder records a bearing 120°, ship's head 030°. Required the true bearing of the station.

Direction of ship's head		030°
Radio angle between ship's head and station		120
True bearing of station	S. 30° E or	150

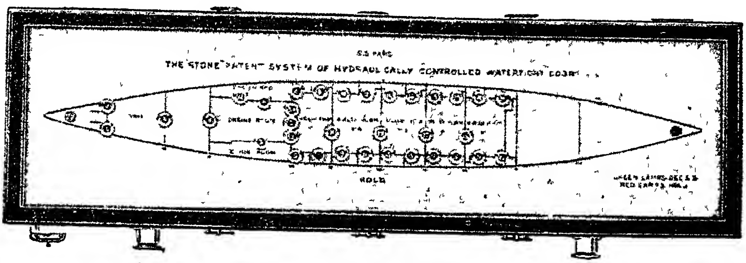
The magnetic field of the ship interferes with the normal direction of the incoming wireless wave, consequently the apparent direction of the distant wireless station is altered. The errors caused are quadrantal, that is to say, they reach a maximum value every 90°, or four maxima and four minima in a complete swing. In a ship having perfect electrical symmetry the induced currents in the structure produce a magnetic field in the athwartship line and the quadrantal error is zero in directions 0°, 90°, 180°, and 270° from the bow, the maximum error appearing at 45° on port and starboard bows and on port and starboard quarters. In most cases, however, the ship's magnetic field is unsymmetrical so that the quadrantal error is zero at four other angles from the bow, but the maximum errors are still separated by 90°. The apparatus is provided with permanent correction adjustment so that the correct angle between the ship's head and the station may be read direct from the scale. There are other types of wireless directional indicators known as radio beacons for transmitting wireless fog signals as described under Notices to Mariners, page 248.

SLUICES AND WATERTIGHT DOORS.

A sluice valve is a watertight vertically sliding shutter over a hole cut in the lower edge of a bulkhead to allow water to flow from one compartment to the next. The valve is raised and lowered by means of a rod secured to it and operated by hand from an upper deck above the waterline. The fewer sluices fitted in a ship the better. None is fitted in the collision bulkhead nor at any other watertight bulkhead unless arranged so as to be at all times accessible. They should be

kept closed at sea and opened and closed frequently to keep them in working order.

But large passenger vessels are divided into numerous compartments by transverse and longitudinal bulkheads, and it is necessary to provide means for passengers and crew to move freely through the intervening bulkheads. Large openings have therefore to be made below the water-



Electrical Indicator. A Light for each Door.

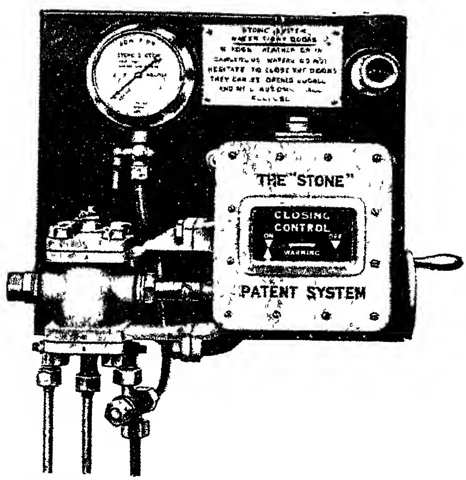
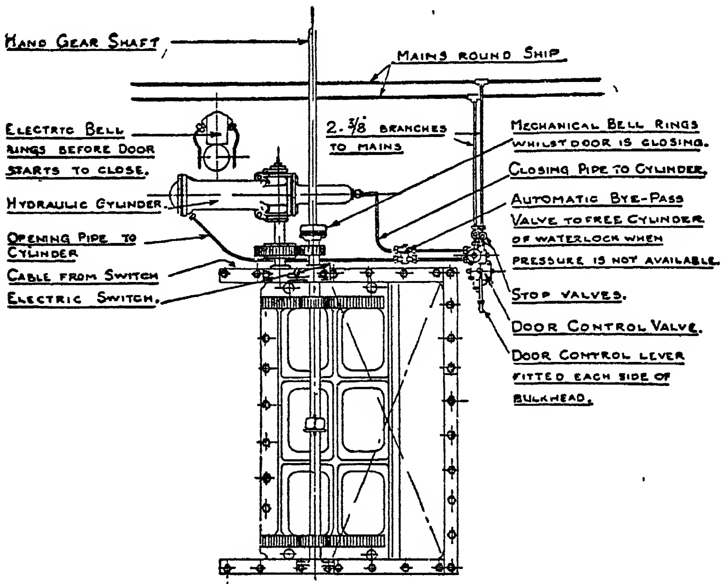


Fig. 20.—Watertight Doors. Control Apparatus in Wheelhouse.

line in some of the bulkheads, and in order that these may be closed and made watertight at a moment's notice the Stone System of hydraulic control for bunker and other sliding bulkhead doors is fitted.

The control apparatus is fitted on the bridge. Figure 20 shows the bridge control and indicator. The officer on a sudden emergency call turns the valve control handwheel, and immediately a pre-warning

signal bell is given at each door, then all doors connected to the system are closed by means of hydraulic rams; and, on the doors reaching their closed positions, glass discs are illuminated in the electrical indicator mounted over the control, thus indicating that the operation has been effected. By reversing the control valve handwheel the doors may be opened again. Each door when closed may be opened by any person wishing to pass through by merely pressing a lever, but immediately the lever is released the door automatically closes again.



TYPICAL ARRANGEMENT OF
HORIZONTAL SLIDING "STONE" WATERTIGHT DOOR.

Fig. 21.

An identification disc is provided for each door showing by its illumination on the indicator in the wheelhouse whether it is closed or open and its particular position in the ship.

The above figure shows a typical arrangement of a horizontal sliding watertight door. The pumping machinery to maintain a constant pressure of water to operate the hydraulic rams is installed in the engine-room.

STEERING GEARS

The simplest form of lever for turning a rudder is the "helm," now known as the "tiller" in small boats. A wheel and axle purchase is substituted in small ships in order to get more power to turn the heavier rudder. It is simply a rope with its middle part wound round a barrel and the ends led through leading blocks at the side of the deck and made fast to the end of the tiller. The steering wheel is on the end of the barrel and when the wheel is turned the barrel with the rope on it is turned also and the rope pulls the tiller to one side or the other.

The figure shows a type of screw steering gear fitted in larger vessels A crosshead *A* is keyed firmly to the rudder head *B*, the crosshead is equivalent to the tiller because when it is turned the rudder post turns. *C* and *C* are the port and starboard rods, the port rod has one end bolted to the crosshead at *A* and the other end to a sleeve D^1. The starboard rod is similarly connected to the crosshead and to the sleeve D^2. The sleeves D^1 and D^2 work, respectively, in right and left-handed screws cut on the common shaft *F*, which is turned by the steering wheel, so that the sleeves move in opposite directions and turn the crosshead.

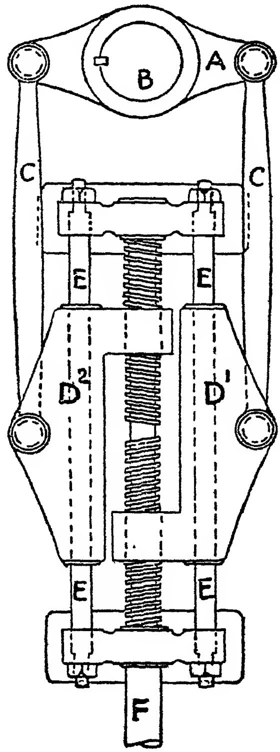


Fig. 22.—Principle of the Screw Steering Gear.

A. The crosshead (equivalent of tiller).
B. Rudder head.
C. Connecting rods.
D. Sleeves working on guide rods *E*.
D^1. Gears with right handed thread and D^2 with left handed thread, both threads being cut on shaft *F*, which is operated in either direction by hand wheel or engine.

The Requirements of a steering gear are, to move the rudder to any position with as little delay as possible; to hold the rudder in position under the stresses imposed in manoeuvring the ship; to give way before any abnormal stress such as caused by a wave, and automatically to return to its former position; to be absolutely reliable. Usually eight turns of the steam steering wheel are required to put the rudder from

hard over on one side to hard over on the other and at least double that number of turns for hand steering gear.

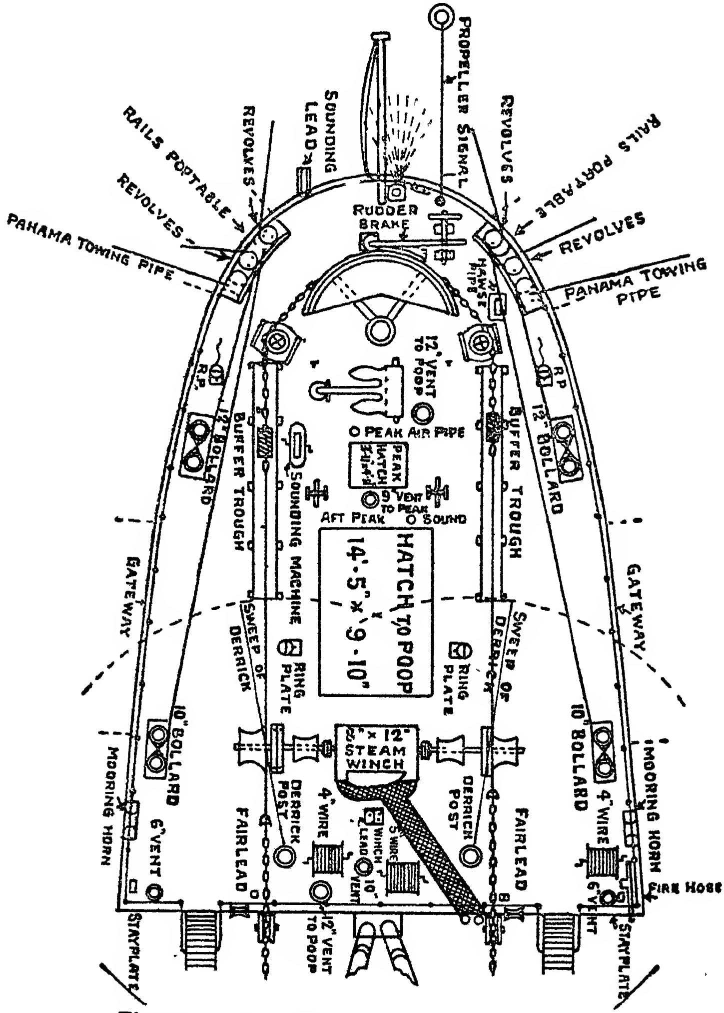


Fig. 23.—Poop fittings of *Caledonian Monarch.*
Note.—Steering chains, spring buffers and the rudder brake on quadrant.
See also page 610.

The principle of the rudder has not altered with the march of progress, but the method of controlling it has to be modified to work the heavier

rudders of the bigger ships. The tiller, or crosshead, or quadrant fitted on the rudder head is now turned by a steam engine. The man operating the steering wheel merely opens and closes a valve which admits steam into the engine Wheel chains are shackled on each side of the quadrant as shown in the plan of the poop of *Caledonian Monarch*, and led along their respective sides of the ship to the drum of the steering engine. The engine turns the drum, the drum coils up the chain on one side and uncoils the chain on the other side and so heaves the quadrant round.

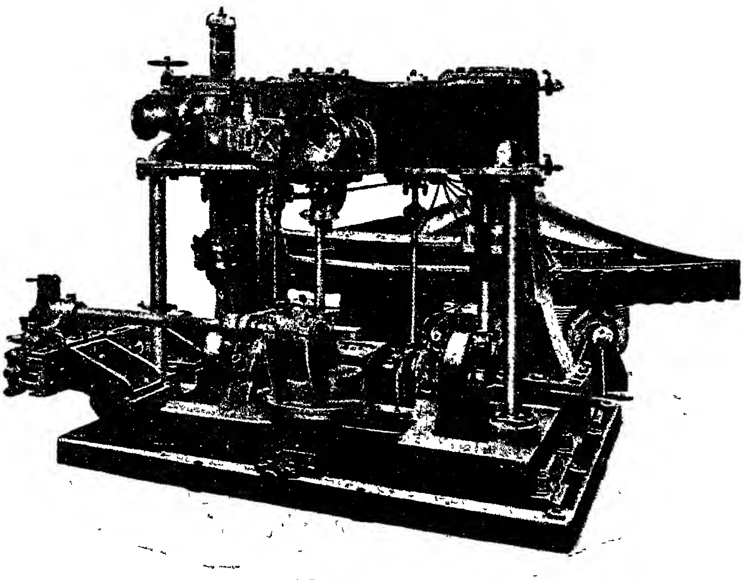


Fig. 24.—Steam Steering Engine Geared Direct to Quadrant.

The Steering Engine may be installed on the bridge but this requires a long length of shafting, spring buffers and chains to connect up with the quadrant, so it is usually placed in the engine-room of ships of moderate size and invariably the engine is geared direct to the quadrant in large vessels. The engine in such cases is operated by the turning of a rod, set in motion by the steering wheel, and which is led downwards and along through various compartments, the continuity of action being maintained by bevelled gearing at the points where the direction of the rod is diverted. These long leads with the bearings, bevelled wheel and sliding joints, absorb a large amount of power in overcoming

frictional resistance, in addition to being noisy where the rods pass through living quarters. In place of rods and chains we now have the valve of the steering engine opened by a lever as before, but the movement of the lever is controlled by hydraulic pressure.

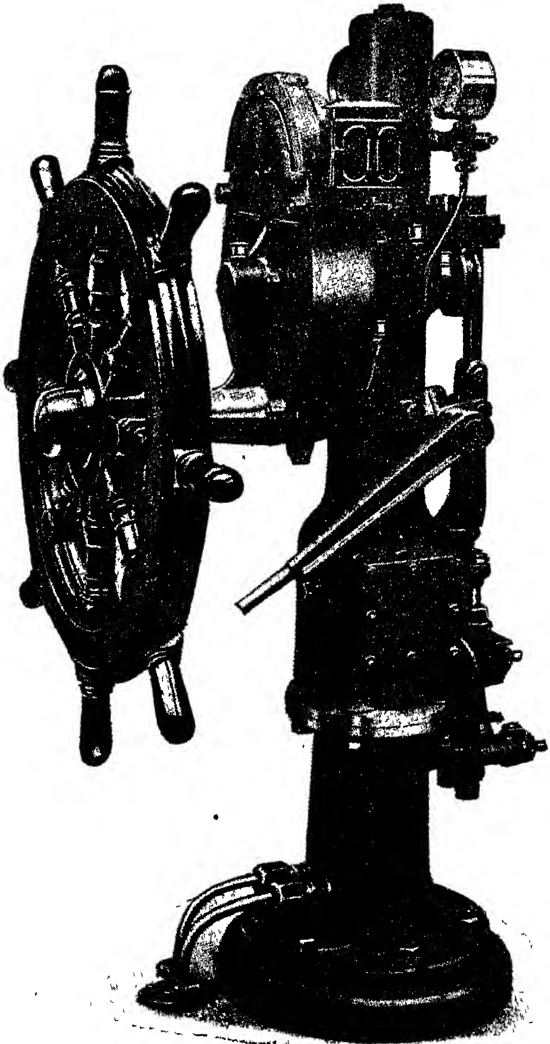


Fig. 25.—Steering Telemotor.

TELEMOTOR STEERING GEAR

The apparatus consists of a **steering telemotor** on the bridge, a **motor telemotor** at the engine geared to the quadrant and **two copper pipes** of small diameter connecting the two gears, the whole system being charged with a special non-freezing liquid.

There are two cylinders with pistons fitted at the steering end and two similar cylinders with pistons at the engine end, the pistons or rams in the corresponding cylinders, port and starboard, being operated by the liquid in the connecting pipes on the principle that liquids are incompressible. The piston ram aft operates the connecting rods and levers, which open and close the steam valves of the engine

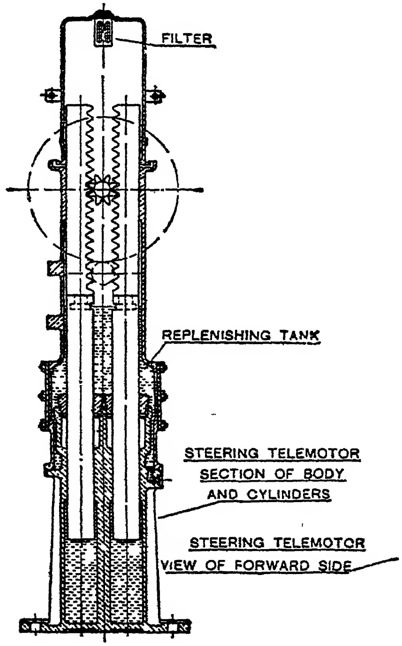


Fig 26.—Transverse Section through Steering Telemotor.

Figure 25 illustrates the Mactaggart-Scott Safety Steering Telemotor. *Note*:—(1) The tell-tale pointer or helm indicator at the upper sector and the two copper pipes leading down through the deck towards the motor telemotor. (2) The pressure gauges to indicate the liquid pressures in each pipe line. Equality of pressure is essential and in this system it

is made by putting the helm amidships and raising the hand lever at the side. The liquid throughout the system is then brought into free communication by means of a bye-pass valve and the pressure automatically equalises itself. (3) The cylinders are vertical as shown by the transverse section (Figure 26). The motion of the steering wheel shaft is transmitted by a rack and pinion gear to the rams, causing the latter to move up and down in the cylinder according to the direction in which the hand wheel is turned from the amidships position.

In the diagram of the pipe system connecting the steering telemotor to the motor telemotor the arrows indicate the circulation of the oil from the charging tank and back again when charging and testing the pipe line.

To Replenish the System.—

1. Disconnect pipes *B* and *C* at the steering wheel and connect temporarily the spare part *BC*, called the wash-out piece.

2. Fill the charging tank with the hydraulic oil which forms a gravity feed to the hand pump.

3. Disconnect pipe *A* at valve *D*, put the end of the pipe into a bucket, work the pump and pass some oil through the pipe. The flow being satisfactory connect up pipe *A* again.

4. Open charging valves *D* and *E*, also liquid saving valves *F* and *G*. Disconnect pipe *C* at valve *G* and put a bucket under the end of it. Continue pumping. The oil will then flow from the pump through the pipes *A*, *B* and *C* in succession and pass into the bucket. Keep pumping for a little time to get a steady flow of oil, thus proving that the pipe line is quite clear. Keep pouring oil into the charging tank at intervals to ensure that air is not being pumped into the pipes.

5. Disconnect pipes *BC* from the wash-out piece and connect to the steering telemotor.

To Charge the System.—

The Steering Telemotor.—Put the wheel amidships and open the by-pass by raising the hand lever. Open valve *J*. Pump until the oil rises in the replenishing tank to the level mark on the gauge glass. Close valve *J*. Release air at air cocks on the pressure gauge pipes.

The Motor Telemotor.—Release air at air cocks *K* on the motor cylinders and continue pumping until for each stroke of the pump a rush of liquid comes from the return pipe *H*. Close charging valve *E*, then charging valve *D*. Open valve *J* at the steering telemotor (this valve should only be closed when charging the system). Release the safety by-pass hand lever. The telemotor is now ready for working.

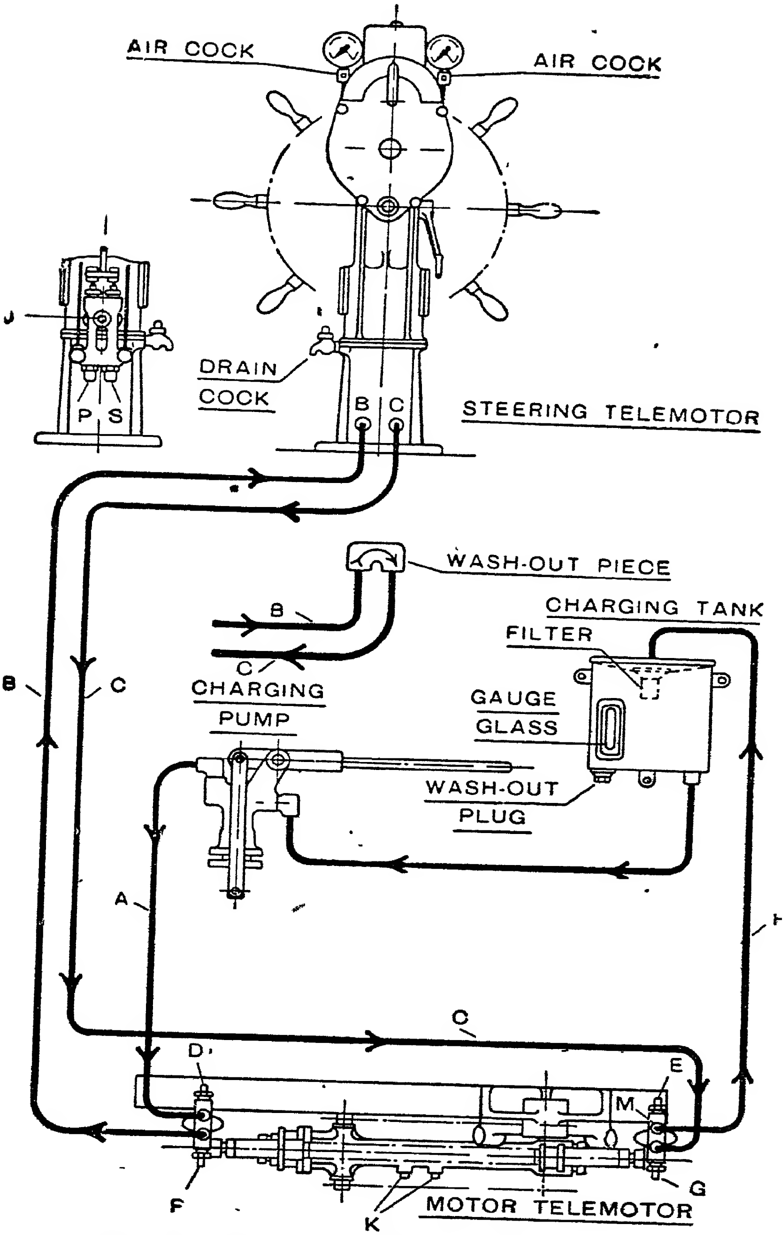


Fig. 27.—Pipe System of Telemotor Steering Gear.

Emergency Steering Gear.—A method of steering the ship alternative to the steam engine gear has to be provided. This sometimes takes the form of hand screw gear, as already described, mounted over the rudder head and geared into the crosshead by dropping in bolts. It is impracticable to steer large vessels satisfactorily by hand gear, so usually two steering tackles are kept ready at hand, one for each side. One block of the tackle is shackled to the end of the quadrant and the other block to a ringbolt directly forward of it, the hauling part being led to the barrel of a winch in substitution of the steering chains. Refer to the poop plan of *Caledonian Monarch* and note the rudder brake on the after side of the quadrant to hold it in position in the event of a breakdown, also that the small inner barrels of the shaft of the winch are intended for the hauling part of the steering tackles (Fig. 23).

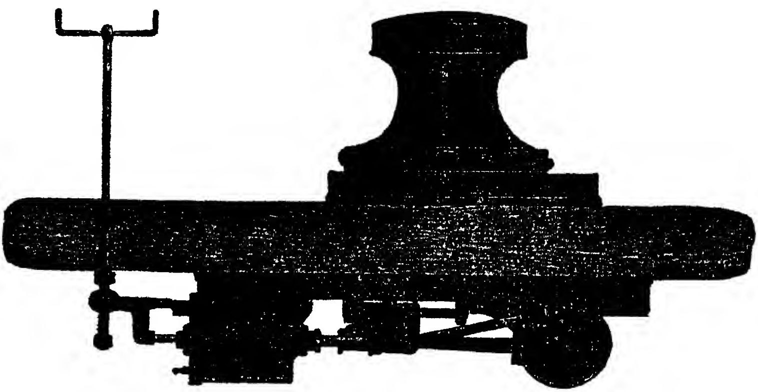


Fig 28.—Steam Capstan.

The chief officer is responsible for the working of deck machinery, but repairs and maintenance are carried out by the engine-room staff. Steam winches are primarily for handling cargo and incidentally for warping the ship alongside piers. They may be either spur-geared or friction-geared, the latter type being designed for quick operating.

The Clutch Winch is employed for quick lowering. The gear wheel is driven by a pinion clutched to the crankshaft, and when the load is raised to the desired height the winch is stopped, the strap brake applied to the drum and the clutch thrown out of gear thus putting the load, when being lowered, under the control of the brake.

The Link Motion Gear is usually adopted for cargo winches. The load is lowered by putting the winch into reverse gear so that the load

is always under the control of the engine. The operation of lowering is slower but safer than trusting to the brake overcoming gravity as in the clutch winch.

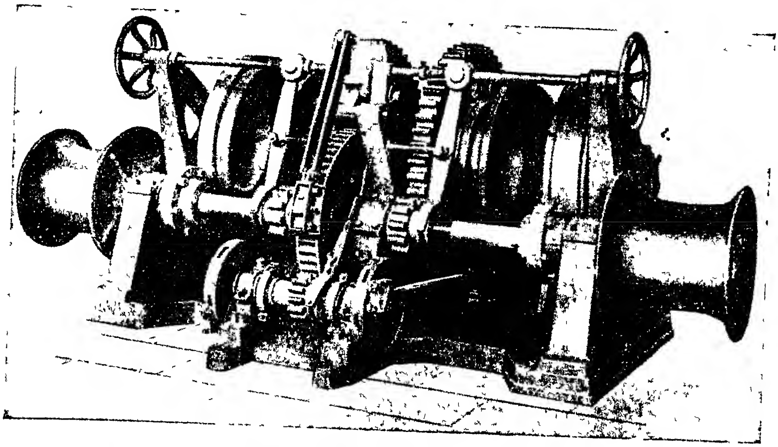


Fig 29 —Windlass Forward Side

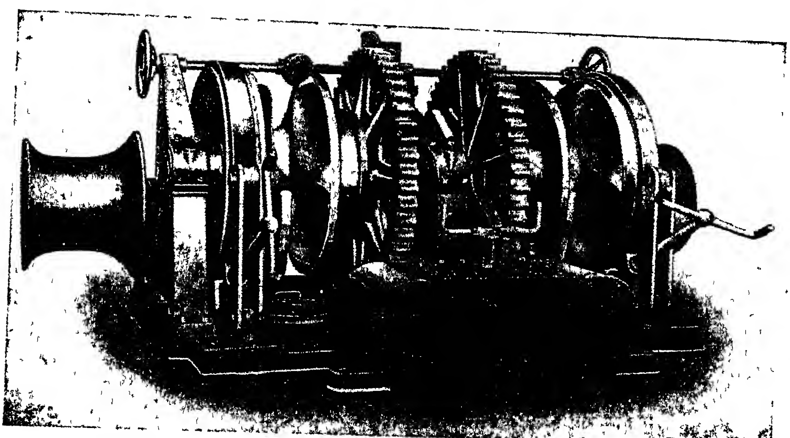


Fig. 30.—Windlass After Side.

Steam Capstan.—Figure 28 illustrates a capstan driven by a steam engine under the deck and controlled from above. The engine works in the same way as an ordinary winch. The oscillating motion of the piston is communicated by the piston rod and crankshaft to the eccentric, and this rotates the horizontal shaft which engages by spur and bevel

gearing with the lower end of the capstan spindle projecting below the deck but not shown in figure. The direction of motion and the stopping and starting of the engine are regulated by turning the vertical rod, which has a thread cut on its lower end to engage with the short horizontal lever operating the steam valves. This engine may be disconnected for warping by hand capstan bars.

The illustrations show the fore part and after part of an Emerson Walker Patent Quick Warping Direct Grip Windlass (Figs. 29 and 30).

Before starting any deck engine, all drain cocks must be opened and steam allowed to blow through the cylinders until they are clear of water. When winches are not in use during frosty weather they must either be kept running slowly or the steam pipes and cylinders freed from water.

Hydraulic cranes and electric winches are fitted in some passenger ships as they are cleaner and less noisy than steam winches.

PROPELLING MACHINERY.

Steam propelling machinery consists of boiler, engine, condenser with auxiliary machines and fittings.

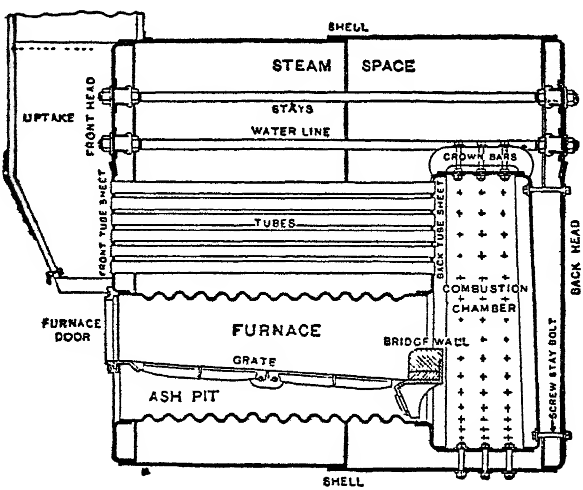


Fig. 31.—Fire-tube or Scotch Boiler.

Boilers are of two types, the Scotch or fire-tube boiler in which the fire passes through tubes surrounded by water, and the water-tube

boiler in which the water circulates inside tubes surrounded by the fire and hot gases. Merchant ships are usually fitted with Scotch boilers, installations of water-tube boilers only being common in warships.

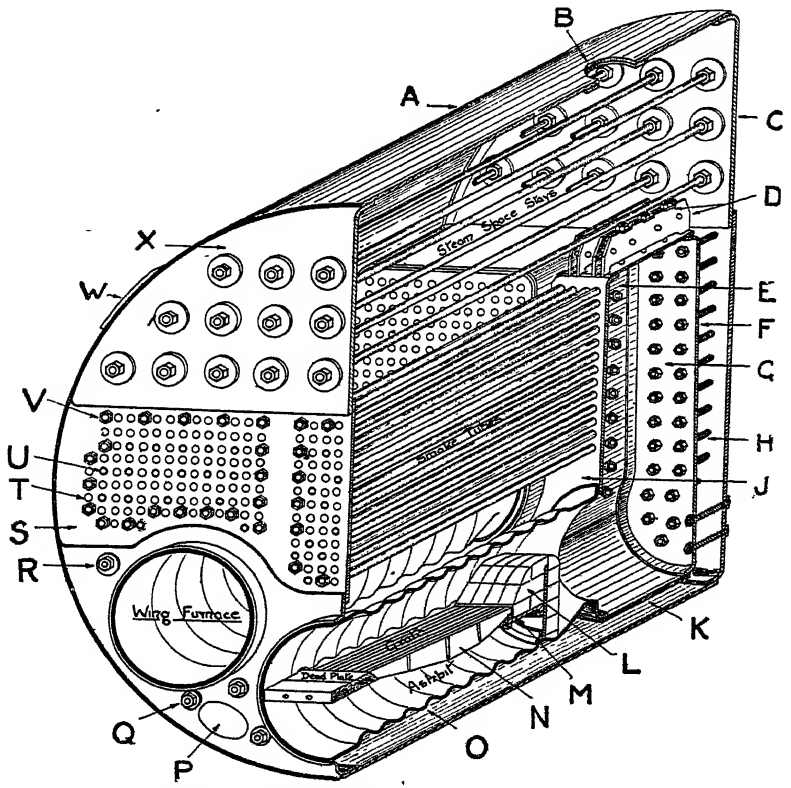


Fig. 31a —Single Ended Scotch Boiler (in section) without Mountings.

A Shell Plate.
B Top Manhole 16″ × 12″.
C End Plate.
D Combustion Chamber Girders and Stays.
E Combustion Chamber Wrapper Plate.
F Combustion Chamber Back Plate.
G Combustion Chamber.
H Combustion Chamber Stays.
J Back Tube Plate.
K Combustion Chamber Bottom Plate.
L Bridge
M Back Bearer.
N Firebars.
O Centre Furnace.
P Bottom Manhole 15″ × 11″.
Q Stay.
R Stay.
S Front Tube Plate.
T Plain Tubes
U Stay Tubes
V Stay Tubes with Nuts.
W Longitudinal Joint Double Butt Strap.
X End Plate

NOTE.—Tubes and Girders omitted on Wing Combustion Chamber for simplicity.

The ordinary marine boiler is said to want less overhauling and repairing than a water-tube boiler, and is better for cargo and passenger steamers and general hard work. It does not require such skilled firing or such constant attention when under steam. The advantages of a water-tube boiler are that it is suitable for higher pressures (often 300 lbs. to the square inch); it is of less weight for the same power; it carries less water; and steam can be raised much quicker, in one hour if necessary.

The heat is generated in the furnace, the top or crown being corrugated to increase the area of heating surface. The heat then passes up the back end, through the boiler tubes and out through the uptake over the furnace doors, the smoke and flue gases passing up the funnel where the temperature may be as much as 600° Fahr. The heating of the funnel causes it to expand so that the funnel guys must be eased up if they become too tight. Sometimes the guys are fitted with springs that require no attention, but when the guys are set up with lanyards to eyebolts on deck care must be taken that they are maintained at a suitable tension.

Reciprocating Engines may be compound, triple or quadruple expansion, the steam passing successively through 2, 3 and 4 cylinders and doing work in each cylinder before exhausting into the condenser.

Turbine Engines are greatly used in warships, and in some passenger vessels. It consists of a cylinder lying in a horizontal position through which the propeller shaft passes. A rotor is secured on the shaft. This rotor is covered with small blades. Steam is admitted which turns the rotor and shafting and consequently the propeller. It revolves at a high speed, and can only turn one way. Another turbine is fitted on the same shaft for going astern.

Figure 32 illustrates a type of reciprocating compound surface condensing marine engine suitable for small ships. *A* is the engine stop valve, *B* the valve lever, *C* the reversing lever which operates, *D* the links and reversing gear, *E* are connecting rods connected to the lower end of the piston rods and to the crank shaft, *F* is a rocking shaft to work the air, feed and bilge pumps at *H*, *G* is the discharge pipe from the condenser and *I* is a manhole door on the end of the condenser. *J* are relief valves on the low pressure and high pressure cylinders, *L* the crank shaft to be coupled to the thrust shaft.

Figure 33 is a diagram to indicate the circulation of the steam. The working pressure in a marine boiler varies with the type and ranges between 160 and 220 lbs. to the square inch. The steam passes through the boiler stop valve, then through the engine stop valve

and then, in succession, through the high pressure piston valve and high pressure cylinder, intermediate pressure slide valve and intermediate cylinder, low pressure slide valve and low pressure cylinder, doing work on the piston of each cylinder as it expands. The slide valves admit steam alternately above and below the piston. The steam then passes

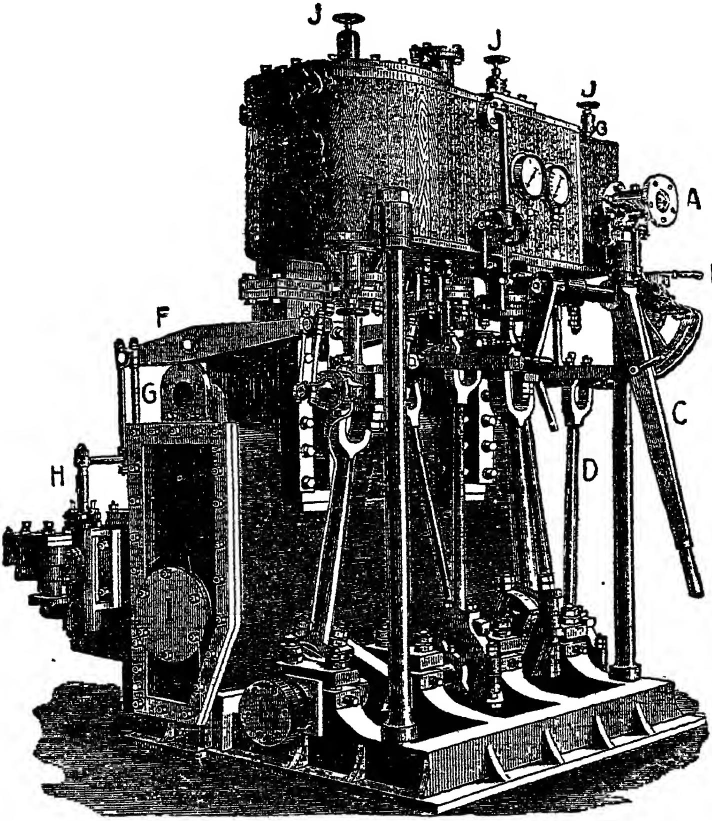


Fig. 32.—Reciprocating Compound Engine.

into the condenser where it is condensed by coming into contact with pipes through which cold sea water is being circulated. The air pump extracts air and water from the condenser and passes the water into a feed tank and from thence it is pumped back into the boiler.

The sea water runs into the condenser through an injection pipe low down on the bilge, the circulation being maintained by a circulating

pump which discharges the sea water again through the discharge pipe high up on the ship's side. This is the water ejected from the side of a steamship under way.

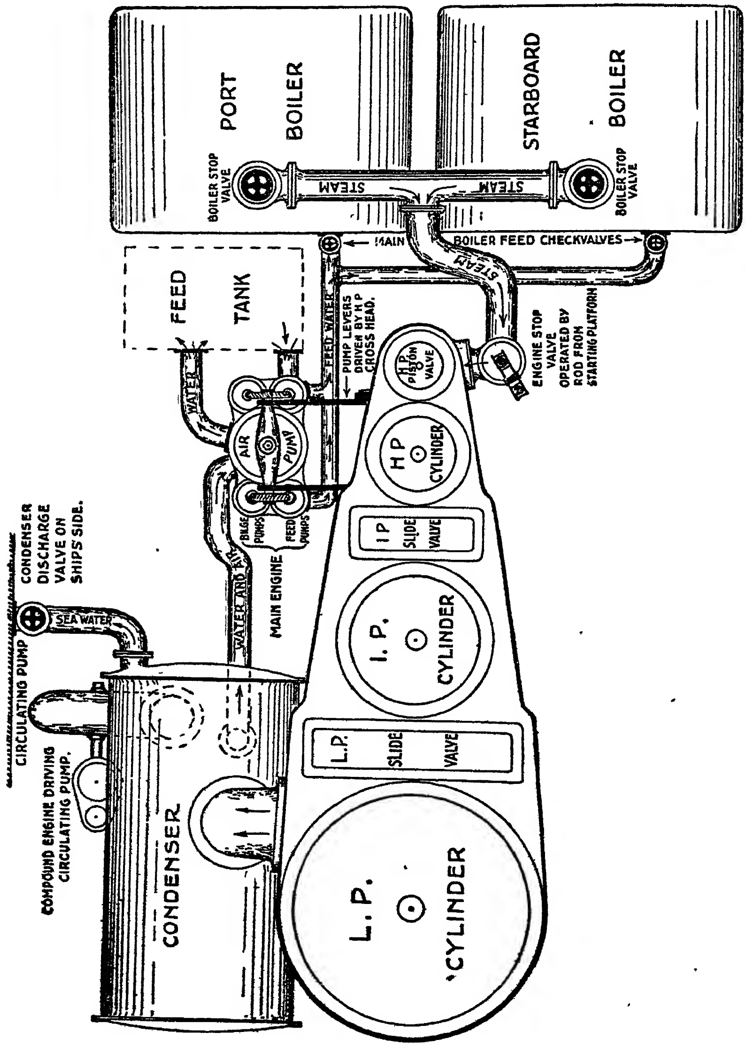


Fig. 33.—Steam Circulation in a Marine Engine.

Figure 34 shows, in section, the cylinders of a set of triple expansion marine engines. *A* is the H.P. slide valve, *B* the I.P. slide valve, *C* the I.P. relief valves, *D* the I.P. piston.

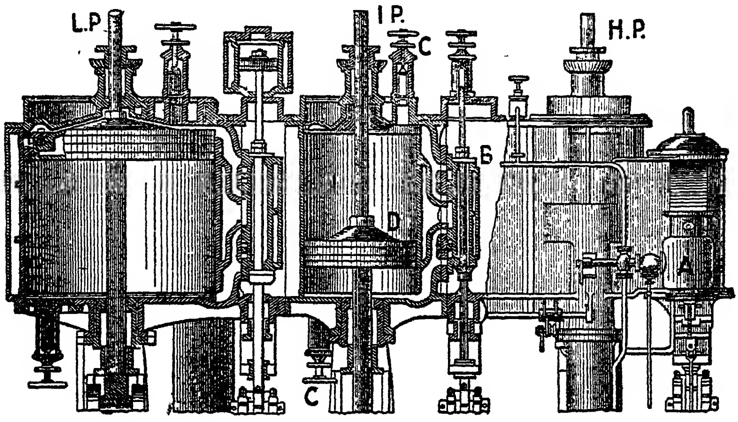


Fig. 34 —Cylinders of a Triple Expansion Engine.

A Motorship is one fitted with internal combustion engines which work on crude oil. There are no boilers connected with it and no steam. A donkey boiler is, however, carried on motor ships to supply steam for winches, heating, etc. Several advantages are claimed for the internal combustion engine over the steam engine of similar power, viz., less space occupied, the weight of the whole plant is much less than a steam engine and boilers, the weight of the liquid fuel carried is less than the coal for the boilers, more cargo can be carried, working expenses are less as there are no boilers or stokers, fewer hands are required to attend to the machinery.

The steamship, however, is more reliable and in some respects is more suitable for certain trades than the motorship. Diesel engines are peculiar in that they can only be started by compressed air and several revolutions are necessary before they become oil fired. This limits, somewhat, the number of startings of the engine when manoeuvring in harbours, and the Board of Trade insist that the capacity of the air receivers should admit of at least 12 consecutive startings of the main engines without replenishment from the compressors.

FIRE.

1. What precautions are usually adopted to prevent fire on board ship?

Smoking in the holds during the loading and discharging of cargo or indeed at any time when there is inflammable material in any compartment should be rigorously prohibited. A match or lighted cigarette carelessly thrown away may smoulder for days before bursting into flame. Wire guards of close mesh placed in ventilator cowls are a safety precaution against the thoughtless action of smokers.

The human sense of smell is utilised with suspicion when passing ventilators and openings leading into holds and peaks, and if there be the slightest indication of smoke or heat emerging from an opening an investigation should at once be made.

Regulations and byelaws relating to the prevention of fire are issued at most ports and rigorously enforced by the authorities, the person in charge of the ship being liable to a heavy fine should the rules not be complied with. Stringent rules are laid down when the cargo is of a highly inflammable nature such as cotton, flax, wool, oil, etc., which may ignite by spontaneous combustion, all persons on board being prohibited from carrying matches, petrol lighters or any appliance for producing ignition, and very often when no inflammable goods are being handled only safety matches are permitted.

Persons engaged loading or discharging explosives must wear rubber boots, and the coamings of hatches, gangways and rails are specially protected with matting and wood so that the packages may not knock against a hard surface.

Storerooms in which paint and anti-fouling compositions are stowed should be well ventilated and no one should enter these spaces with naked lights. The same precautions should be taken in cargo spaces especially where coal or oil is, or has been, carried. The ship's electric wiring is insulated and led through pipes or protected by casing.

2. What arrangements are made to cope with an outbreak of fire on board ship at sea?

The provision made in cargo steamships is the usual deck water circulation with the hose coupled up in lengths and connected to the hydrants on water pipes, with at least 12 fire buckets and occasionally some portable chemical fire extinguishers placed in convenient positions.

The Board of Trade has issued instructions regarding the proper provision of fire extinguishing appliances. These recommendations

have been adopted by the International Convention for the Safety of Life at Sea, and are to take effect when ratified.

3. Describe how steam is injected into a hold in the event of fire.

Forcing steam into the hold will keep down combustion if it does not actually put out the fire. The ends of suitable pipes are coupled to the winch steam pipes on deck, the other ends being inserted into the hold either by way of the ventilators, or the hold sounding pipes which should have holes perforated in their lower ends, or through holes cut in the hatches or deck as near to the seat of the fire as possible. All hatches and openings into the compartment must be covered to prevent any oxygenised air getting in. The pressure and the volume of steam admitted into the hold should be capable of forcing its way into the air spaces and escaping through any crevices or leakages in the walls of the compartment, thus preventing the admission of air. The temperature of the hold will, of course, rise as evidenced by the heating of decks and bulkheads, but the object is to keep the fire from bursting into flame, and cases are on record where this method has kept the fire smouldering slowly for days and weeks until the ship arrived in port and only on opening the hatches has the fire become active. In some cases the fire has been put out, the charred remains of packages in the hold testifying to the effectiveness of steam in absorbing the oxygen in the hold.

4. Describe some types of fire extinguishers.

Portable Chemical Fire Extinguishers are universally known. They are manufactured to approved specifications and have a capacity up to 3 gallons as that is the largest size that can be handled usefully by one man. The liquid in the cylinder is contained under pressure, about 200 lbs. per square inch, and squirts out when the valve is opened. The charge may be (1) a solution of sodium bicarbonate or potassium carbonate and a jar or bottle containing either sulphuric or hydrochloric acid; (2) a capsule of compressed carbon dioxide, CO_2, of sufficient quantity to make the fresh water in the cylinder an effective chemical extinguisher and to exert sufficient pressure to be able to eject the whole fluid a distance of 20 to 30 feet for a period of not less than 60 seconds.

"Firefoam" is another extinguishing medium which is specially effective in the case of oil fire originating in engine and boiler spaces or in tanks. Oil, in quantity, burns on the surface of water so that a solid jet of water from a nozzle when turned on to the flames merely causes

the burning oil to spread by washing it into corners or into adjacent compartments, hence the reason for spraying the water on an oil fire.

Firefoam is contained in portable cylinders, and when discharged at the spot it froths, spreads, envelops the surfaces, smothers the flames it comes in contact with and prevents the ignited oil from overflowing into other compartments.

Fixed Fire Extinguishing Systems usually consist of a battery of cylinders filled with carbon dioxide gas (CO_2) at a pressure round about 900 lbs. to the square inch. A system of pipes leads from the cylinders to the various compartments and cargo spaces, by way of the wheelhouse as a rule, where a detecting cabinet is fitted.

In the Lux-Rich system a partial vacuum is maintained in the chamber of the cabinet by a small exhauster, the suction of which continuously draws air samples from all compartments of the ship, one pipe being fitted for each cargo space. Smoke, drawn from a tube in the detecting cabinet, is the warning that tells of the existence of fire in a particular compartment, and a lighting arrangement makes the slightest amount of smoke strikingly visible to anyone in the wheelhouse, a further warning being given by the smell of the exhaust air flowing from the vacuum chamber.

When fire is detected the extinguishing gas from the cylinders is introduced into the detection pipe by means of a three-way valve. The valve shuts off the air flowing up from the cargo spaces to the detector and connects the holds with the carbon dioxide which flows direct from the cylinders along the same pipe, the gas on emerging from the pipe into the hold expands rapidly and penetrates into crevices and the inaccessible places, thus flooding the burning compartment with the released gas and smothering the flames or smouldering mass.

In both the Clayton and the Harper systems the gas is pumped into the cargo spaces and these systems may also be used for fumigating the ship.

5. What would you do in the event of fire breaking out, the ship being at sea?

Give the particular alarm signal as recognised on board the ship, usually a succession of 6 short blasts followed by 1 long blast on the whistle. Treat the fire as a serious one from the very first. All fires, like human beings, begin in a small way. Try to locate the source of the fire; hands to stations and couple up the hoses.

If the fire can be got at and is found to be small, turn on a fire

extinguisher, but if it is too big for that I would turn on the water and drown it out. Should, however, it be a deep seated fire and inaccessible, I would close all ventilators and openings into the cargo space and inject steam into the hold. Ships fitted with refrigerating plant usually carry cylinders of CO_2 gas. I would inject a few cylinders of this gas into the hold, introducing it through holes in the bulkheads. Should the ship be fitted with a special fire smothering system I would turn it on to the affected hold immediately the fire was discovered, making sure that all persons were out of the compartment before doing so.

If the fire were a serious one and had got out of hand, threatening danger of a conflagration or explosion, I would swing out the boats and have everything ready for abandoning ship. Intimate the facts of the case by wireless telegraphy. Head the ship for the nearest port or beach should she be near the coast.

I would keep in mind that water sprayed on burning oil from a nozzle having perforations is more effective than a stream of water.

FIRE APPLIANCES as RECOMMENDED by the BOARD OF TRADE

Foreign-going Cargo Ships.

(*a*) **Steamships of 2000 gross tonnage and upwards.**—At least two steam or equivalent pumps shall be available, each of which is capable of providing a full supply of water to a range of metal service pipes, fitted with branches at intervals of about 60 feet so arranged that the fire hoses, of which two shall be provided, may be readily coupled thereto, and two powerful jets of water may be rapidly and simultaneously brought to bear upon each space occupied by officers and crew, or upon any part of each cargo space, or upon each coal bunker space.

In addition, satisfactory means shall be provided whereby steam may be conveyed to each closed-in cargo compartment.

Two smoke helmets of an approved type (stowed in separate places) and 12 fire buckets shall be provided.

All foreign-going cargo steamships shall have at least two chemical fire extinguishers in each compartment of the machinery space where oil is used. A portable chemical fire extinguisher shall be available for immediate use in each space occupied by the officers and crew, but the total number provided for these spaces need not exceed six.

In all vessels which use oil fuel, in addition to the water service to

these spaces, satisfactory provision shall be made for the admission of steam to the lower part of the boiler rooms.

A receptacle containing a suitable quantity of sand shall be placed in each firing space where oil fuel is used, and suitable scoops for distributing the sand shall also be provided.

In the case of steamships carrying deck cargoes, the fire service pipes must be so arranged that the required number of hydrants are always accessible.

Fire Hose.—The fire hoses may be made of leather, seamless hemp or flax canvas of first-class quality, or other approved material. There shall be provided 50 per cent. more than the minimum quantity necessary to meet the requirements of the previous rules and the following clause. The hoses shall be provided with suitable metal unions and conductors, and with gooseneck connections where necessary, and shall be of such length that when in position a jet of water may be projected to any part of the space in which they are used.

The fire hoses, conductors, etc., shall be kept ready for use, in conspicuous positions near the water service connections, and shall be used only for the purpose of extinguishing fires, or for testing the apparatus at fire drills and surveys.

Pipes to Holds, etc.—The pipes for conveying steam to holds or other compartments shall be provided with controlling valves suitably marked to indicate the compartments to which the pipes are respectively led. Suitable provision shall be made for locking these valves, as a precaution against the inadvertent admission of steam to any compartment. If any pipe is led to a space to which passengers have access, it shall be furnished with an additional stop valve, capable of being locked, or some other device providing the requisite security from danger should be adopted.

Portable Chemical Fire Extinguishers.—The recommendations with regard to chemical fire extinguishers apply only to apparatus of an approved fluid type, the capacity of which shall not be, as a rule, less than 2 gallons.

The extinguishers on any vessel shall not be of more than two kinds. They shall be kept where likely to prove most serviceable in cases of emergency, and shall bear on each apparatus printed instructions regarding its use, and the maker's dated guarantee as to the sufficiency of the extinguisher for the pressure generated when it is put into action.

Fire Drill.—Fire drill shall be observed at least once a month in all foreign-going cargo vessels. The great utility of woollen or asbestos

blankets for smothering small fires should always be borne in mind at fire drills.

Annual Inspection.—The fire-extinguishing appliances shall be thoroughly examined by an approved Surveyor at least once every 12 months.

At these inspections *all* the fire hoses, both working and spare, shall be tested under working conditions, and any defects which may be discovered shall be made good to the Surveyor's satisfaction.

A fair proportion of the chemical fire extinguishers shall likewise be tested (if possible in the presence of the men likely to use them in case of emergency): and afterwards recharged, or, if considered to be defective replaced by new ones. Before testing a chemical fire extinguisher, the Surveyor shall carefully examine the apparatus and satisfy himself as to its sufficiency for the pressure which it may have to sustain, and for this purpose the charge shall be withdrawn.

Muster List.—The muster list assigns duties to the different members of the crew in connection with:—

(*a*) The closing of watertight doors, valves, etc.

(*b*) The equipment of the boats, life-rafts and buoyant apparatus generally.

(*c*) The launching of the boats attached to davits.

(*d*) The general preparation of the other boats, the life-rafts and buoyant apparatus.

(*e*) The muster of the passengers.

(*f*) The extinction of fire.

The muster list also assigns to the members of the stewards' department their several duties in relation to the passengers at a time of emergency.

(*a*) Warning passengers.

(*b*) Seeing that they are dressed and have put on their life-jackets in a proper manner.

(*c*) Assembling the passengers at muster stations.

(*d*) Keeping order in the passages and on the stairways, and, generally, controlling the movements of the passengers.

Musters and Drills.—Musters of the crew for boat drill shall take place weekly when practicable, and in vessels in which the voyage exceeds one week, before leaving port.

Different groups of boats shall be used in turn at successive boat drills. The drills and inspections shall be so arranged that the crew

thoroughly understand and are practised in the duties they have to perform, and that all life-saving appliances with the gear appertaining to them are always ready for immediate use.

STANDING RULES FOR STEAM VESSELS AT SEA

Officer of the watch to keep his look-out on the bridge, not leaving it except when necessary. At night he will be careful to see, from time to time, that the side and masthead lights are burning brightly, and kept trimmed; that the look-out man is at his post, and that the ship is steered her course. Where an order book is not kept, the course given to be marked on the log slate (which should always be kept in the chartroom), the officer relieving to examine same before taking charge. The bearing of the North star to be noted frequently and entered in the log, with the direction of the ship's head at the time of observation. Amplitudes and Azimuths never to be neglected. All courses given are by the bridge or standard compass. The officer in charge of the deck to observe if any change or difference takes place between any or either of the compasses, *i.e.* more than usual, if so, call the master. The patent log should be read every two hours and entered up, mechanism to be oiled at least once a day (at noon) by the quartermaster who should report having done so to the officer of the watch.

Barometer registered every four hours and to be frequently noted during unsettled weather. Masters and officers are respectfully requested never to forget the four L's—LEAD, LOG, LATITUDE and LOOK-OUT. No chartroom ought to be without the celestial maps hung up.

The master, when leaving the deck for rest, shall see that chart is on the table for the use of the officer in charge, with instructions to be called on all occasions of doubt.

Pump wells to be sounded by carpenter at 8 a.m. and at 8 p.m., and to be reported to chief officer who reports same to captain previous to making eight bells; and wells to be sounded not less than once in four hours during bad weather, any unusual quantity of water to be reported to captain and engineer of watch. Carpenter to note soundings on the board (where one is kept) in addition to verbal report. Officer of the watch to report changes of weather, particularly so in cases of fog, heavy rains and haze, a large number of ships, or anything unusual connected with the ship, such as thick volumes of smoke going right ahead, so that the course may be altered if prudent to do so.

Watch on deck to be kept round the wheelhouse, so as to be ready

for officer's orders, and save him from leaving the bridge to look for the hands.

Master, officers, and carpenter to see that all steering gear is in working order.

Chief officer to see that the forecastle is cleaned out at proper times; also to see the winches are always in working order.

Carpenter to work all sluice valves once a week, and as a rule keep them closed at sea, except when wanted to run water to engine-room.

Carpenter to look after all tarpaulins and wedges for hatchway battens, and during fine weather the ventilator covers are to be taken off, also one hatch from each hatchway, and to be closed again before dark. Chief officer to see that the coal trimmers keep the grating on bunker holes, and put covers on every evening coming in dark; any neglect of this to be reported to the chief engineer.

The ash shoot is to be used for the purpose of keeping the ship clean.

GENERAL RULES TO BE OBSERVED ON BOARD SHIP IN PORT OR AT ANCHOR.

Deck never to be left without a look-out. The officer to see that the anchor lamp is burning brightly and to be on deck at the turn of the tide when the ship is swinging round. Watch for ship dragging anchor by noting if bearings of shore objects remain the same; pay out cable if it comes on to blow; ring the bell if it comes on fog.

Chief officer has general charge, and will see that a proper account of cargo and stores is kept both in taking in and discharging, and also see that the carpenter looks at limbers, and sees that the pumps are all clean and tank cocks in working order, and all scuppers clear in 'tween decks before cargo is stowed there.

Second officer, and also third, will be under directions of chief, either to tally cargo or to look after holds, and, if necessary, to keep a hold book. Ship never to be left without an officer on board except in harbour or dock, and not then until the watchman takes charge, and watchman not to leave until one of the officers returns.

QUESTIONS.

1 What are the usual commands on bridge telegraphs (*a*) to the engine room, (*b*) to the officer aft when docking?

2. Describe how a telegraph works.

3. What is a navigation light sentinel?

4. Describe the marks on the hand lead line and on the deep sea line.

5. What soundings would you call out for:—(*a*) leather with a hole in it; (*b*) first red rag 6 feet below the surface; (*c*) blue rag 6 feet above the surface; (*d*) second white rag 3 feet above the surface; (*e*) second red rag 18 inches below the surface?

6. Describe how a cast of the deep sea lead would be taken steaming before the wind and sea.

7. Describe taking a cast with a patent depth recorder. How can you tell when the lead has touched bottom?

8. What is the principle of the atmospheric sounding tube.

9. Write out the best description you can of the Echo Sounding Machine.

10. What is the principle followed in measuring off the length of the knot on the hand log line?

11. Describe a patent towing log.

12. Describe any electrical type of speed recorder you may know about.

13. Supposing all speed recorders were lost how could you arrive at the ship's speed?

14. Write out equations connecting the ship's speed with coal consumption.

15. Describe a sluice valve, how it is operated and the manner in which they are fitted.

16. What are the requirements of a steering gear?

17. Describe a type of steam steering gear and how the rudder is operated by the helmsman.

18. What advantages are claimed for telemotor steering gear? Describe how it works.

19. Describe the emergency steering gear in any ship you have served in.

20. Describe the mechanism of a steam winch and how it works. What precautions should be taken before starting and stopping a winch, particularly so in cold weather. Steam is escaping badly from the cylinders of a winch, describe how you would repack the glands and make it steamtight.

21. Name the essential parts of a reciprocating marine steam engine.

22. What are the fundamental differences between a Scotch boiler and a water-tube boiler? State the advantages and disadvantages of each.

23. Describe the fundamental differences in the working principles of a reciprocating steam engine and a turbine steam engine.

24. Trace the complete circulation of the steam from the boiler and back again and what it does at successive stages of its journey.

25. State what you know of a motorship and the advantages claimed for the internal combustion engine

26. Describe the construction and principle of a mercurial barometer.

27. What precautions must be taken when mounting and unmounting a barometer for transport?

28. What is (*a*) a millibar, (*b*) a vernier?

29. What is "error of capacity" and why is it not applied to readings of the marine type of barometer?

30. Describe an aneroid barometer. How does it differ from a mercury barometer?

31. How may an aneroid be converted into a barograph?

32. Write down the freezing and boiling temperatures of fresh water as indicated on the Fahrenheit, Centigrade and Absolute scales.

33. How is zero temperature Absolute arrived at?

34. Convert 132° Fahr. into Centigrade and Absolute.
60° Centigrade into Fahrenheit and Absolute.
150°. Absolute into Fahrenheit and Centigrade.

35. Describe the maximum and the minimum thermometers and state how these extremes are recorded.

36. Describe the construction, principle and use of a hygrometer.

37. In what kind of weather would you expect the greatest differences in the wet and dry bulb thermometers? Which reads the lower?

38. What is a rain gauge? What is meant by 1 inch of rainfall?

39. Explain a method of receiving a wireless telegraphy directional bearing on board ship. Is any correction of the radio bearing necessary to obtain the true bearing of the distant station?

40. What standing orders are usually observed on board ship (*a*) at sea, (*b*) at anchor, (*c*) in dock?

41. Describe the fire-extinguishing appliances on board your ship.

42. The seat of fire in a hold is inaccessible, what steps might be taken to subdue it?

43. How is a chemical fire extinguisher worked?

44. What is "Firefoam" and how is it used?

45. Describe any fire detecting and extinguishing system you know of.

46 Describe the procedure of any organised fire drill you have taken part in and the duties of the various members of the crew.

47. How often is the fire-extinguishing apparatus inspected?

48 Assuming the emergency signal to have been made on the steam whistle at sea, "all hands and passengers muster at stations," state what particular duties should be performed by the members of (*a*) the deck department, (*b*) the engine department, (*c*) the cabin department.

49. A steamer burns 24 tons of fuel per day when steaming 8 knots, find the approximate consumption if speed is increased to 9 knots and again to 10 knots.

Ans.—34 tons; 47 tons.

50. The consumption at 12 knots being 40 tons per day, find what the approximate consumption will be if speed is reduced to 10 knots.

Ans.—23·1 tons.

51. A steamer has accomplished 1200 miles at 10 knots with a consumption of 140 tons of fuel, she has still 1400 miles to go with only 100 tons left. Required the reduced speed to reach destination.

Ans.—7·8 knots.

52. A vessel has steamed 1500 miles at 10 knots burning 40 tons of coal daily, find her consumption to do 12 knots if she had 1200 miles to complete the passage.

Ans.—288 tons or about 69 tons per day.

53. Name the three corrections to be applied to barometer readings to reduce them to standard, and state why they are necessary.

54. What is the error of capacity and why is it not necessary to apply it to marine barometers?

55. Describe hydraulic water-tight doors as usually fitted in large passenger steamers.

56. What conditions must an approved steering gear fulfil?

57. State the more important of the General Standing Orders adopted in all well conducted ships (*a*) at sea, (*b*) at anchor, (*c*) in dock.

CHAPTER IX.

REGULATIONS FOR PREVENTING COLLISIONS AT SEA

Their vital importance.—The very object of these Regulations, viz., the Prevention of Collisions at Sea, is sufficient to indicate their vital importance, and should impress upon everyone who wishes to be capable of taking charge of a vessel at sea the absolute necessity of being thoroughly familiar with them.

Their importance at sea is duly reflected in the examination room where they form the most important feature of the *viva-voce* examination of masters and mates. Candidates should note this, and bear in mind the fact that the examination in this subject will be a very rigorous one.

The Regulations should be committed to memory.—The question is frequently asked: "Must I learn the articles word for word?" Now although in many of the subjects of examination the committing to memory of fixed rules or answers is not to be recommended, but rather the reverse, with these Regulations it is different. Here the precise wording has been definitely fixed, and any alteration or misplacement of the wording may entirely alter their meaning, therefore it is important to be exact; also candidates may be asked to repeat any of the Articles.

But you must not suppose that merely being able to repeat them is sufficient. The meaning of each Article must be understood as well as their relation to each other, and as a seaman you must understand their practical application. The examiners are careful to see that such is the case before granting any candidate a certificate.

We have sectioned off the subject into three chapters.

In Chapter IX. the full text of Articles 1 to 16 is given dealing with lights and fog signals, then a brief resume of each Article with illustrations followed by a few questions and answers.

In Chapter X. the full text of the remaining Articles, 17 to 31, Steering and Sailing Rules, is given followed by a few questions and answers.

Then numerous illustrations and exercises on the probable direction a vessel showing her sidelights may be heading and what to do under various circumstances.

This section should be carefully studied and read over and over again. The relative conditions must be intelligently visualised, for there is no other way of becoming thoroughly familiar with the examination side of the Rule of the Road at Sea.

Chapter XI. deals with the Notices to Mariners, system of buoyage and various supplementary regulations for adding to the safety of life and property at sea.

REGULATIONS FOR PREVENTING COLLISIONS AT SEA.

Preliminary.

These Rules shall be followed by all vessels upon the high seas and in all waters connected therewith, navigable by sea-going vessels.

In the following Rules every steam vessel which is under sail and not under steam is to be considered a sailing vessel, and every vessel under steam, whether under sail or not, is to be considered a steam vessel.

The word "steam vessel" shall include any vessel propelled by machinery.

A vessel is "under way" within the meaning of these Rules when she is not at anchor, or made fast to the shore, or aground.

Rules Concerning Lights, etc.

The word "visible" in these Rules, when applied to lights, shall mean visible on a dark night with a clear atmosphere.

Lights.

Art. 1.—The Rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Steam Ships.

Art. 2.—A steam vessel when under way shall carry—

(a) On or in front of the foremast, or if a vessel without a foremast, then in the fore part of the vessel, at a height

above the hull of not less than 20 feet, and if the breadth of the vessel exceeds 20 feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than 40 feet, A BRIGHT WHITE LIGHT so constructed as to show an unbroken light over an arc of the horizon of 20 points of the compass, so fixed as to throw the light 10 points on each side of the vessel, viz., from right ahead to 2 points abaft the beam on either side, and of such a character as to be visible at a distance of at least 5 miles.

(*b*) On the starboard side a GREEN LIGHT so constructed as to show an unbroken light over an arc of the horizon of 10 points of the compass, so fixed as to throw the light from right ahead to 2 points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least 2 miles.

(*c*) On the port side a RED LIGHT so constructed as to show an unbroken light over an arc of the horizon of 10 points of the compass, so fixed as to throw the light from right ahead to 2 points abaft the beam on the port side, and of such a character as to be visible at a distance of at least 2 miles.

(*d*) The said green and red side-lights shall be fitted with INBOARD SCREENS projecting at least 3 feet forward from the light, so as to prevent these lights from being seen across the bow.

(*e*) A steam vessel when under way may carry AN ADDITIONAL WHITE LIGHT similar in construction to the light mentioned in sub-division (*a*). These two lights shall be so placed in line with the keel that one shall be at least 15 feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

Steam Vessels When Towing.

ART. 3.—A steam vessel when towing another vessel shall, in addition to her side-lights, carry TWO BRIGHT WHITE LIGHTS in a vertical line one over the other, not less than 6 feet apart, and

when towing more than one vessel shall carry AN ADDITIONAL BRIGHT WHITE LIGHT 6 feet above or below such lights, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds 600 feet. Each of these lights shall be of the same construction and character and shall be carried in the same position as the white light mentioned in Article 2 (*a*), except the additional light, which may be carried at a height of not less than 14 feet above the hull.

Such steam vessel may carry A SMALL WHITE LIGHT abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

Vessels not under Command and Cable Ships.

ART. 4.—(*a*) A VESSEL which from any accident is NOT UNDER COMMAND shall carry at the same height as the white light mentioned in Article 2 (*a*), where they can best be seen, and, if a steam vessel, in lieu of that light, TWO RED LIGHTS, in a vertical line one over the other, not less than 6 feet apart, and of such a character as to be visible all round the horizon at a distance of at least 2 miles; and shall BY DAY carry in a vertical line one over the other, not less than 6 feet apart, where they can best be seen, TWO BLACK BALLS OR SHAPES, each 2 feet in diameter.

(*b*) A vessel employed in laying or in picking up a telegraph cable shall carry in the same position as the white light mentioned in Article 2 (*a*), and, if a steam vessel, in lieu of that light, THREE LIGHTS in a vertical line one over the other, not less than 6 feet apart. The highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character as to be visible all round the horizon, at a distance of at least 2 miles. BY DAY she shall carry in a vertical line one over the other, not less than 6 feet apart, where they can best be seen, THREE SHAPES not less than 2 feet in diameter, of which the HIGHEST AND LOWEST shall be GLOBULAR in shape and RED in colour, and the MIDDLE ONE DIAMOND in shape and WHITE.

(*c*) The vessels referred to in this Article, when not making way through the water, shall not carry the side-lights, but when making way shall carry them.

(*d*) The lights and shapes required to be shown by this Article are to be taken by other vessels as signals that the vessel showing

them is not under command and cannot therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in Article 31.

Sailing Vessels and Vessels being Towed.

ART. 5.—A SAILING VESSEL under way, and ANY VESSEL BEING TOWED, shall carry the same lights as are prescribed by Article 2 for a steam vessel under way, with the exception of the WHITE LIGHTS mentioned therein, WHICH THEY SHALL NEVER CARRY.

Small Vessels in Bad Weather.

ART. 6.—Whenever, as in the case of small vessels under way during bad weather, the green and red side-lights cannot be fixed, these lights shall be KEPT AT HAND LIGHTED and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than 2 points abaft the beam on their respective sides.

To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the colour of the light they respectively contain, and shall be provided with proper screens.

Lights for Small Vessels.

ART. 7.—Steam vessels of less than 40, and vessels under oars or sails of less than 20 tons, gross tonnage, respectively, and rowing boats, when under way, shall not be obliged to carry the lights mentioned in Article 2 (*a*) (*b*) and (*c*), but if they do not carry them they shall be provided with the following lights:—

1. Steam vessels of less than 40 tons shall carry—

   (*a*) In the fore part of the vessel, or on or in front of the funnel, where it can best be seen, and at a height above the gunwale of not less than 9 feet, A BRIGHT WHITE LIGHT constructed and fixed as prescribed in Article 2 (*a*), and of such a character as to be visible at a distance of at least 2 miles.

   (*b*) GREEN AND RED SIDE-LIGHTS constructed and fixed as

prescribed in Article 2(*b*) and (*c*) and of such a character as to be visible at a distance of at least 1 mile, or a COMBINED LANTERN showing a green light and a red light from right ahead to 2 points abaft the beam on their respective sides. Such lantern shall be carried not less than 3 feet below the white light.

2. Small steamboats, such as are carried by sea-going vessels, may carry the white light at a less height than 9 feet above the gunwale, but it shall be carried above the combined lantern mentioned in sub-division 1 (*b*).

3. Vessels under oars or sails, of less than 20 tons, shall have ready at hand a LANTERN WITH A GREEN GLASS ON ONE SIDE and a RED GLASS ON THE OTHER, which on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

4. Rowing boats, whether under oars or sail, shall have ready at hand a LANTERN SHOWING A WHITE LIGHT, which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this Article shall not be obliged to carry the lights prescribed by Article 4 (*a*), and Article 11, last paragraph.

Pilot Vessels.

ART. 8.—Pilot vessels, when engaged on their station on pilotage duty, shall not show the lights required for other vessels, but shall carry A WHITE LIGHT AT THE MASTHEAD, visible all round the horizon, and shall also exhibit a FLARE-UP LIGHT or flare-up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side-lights lighted, ready for use, and shall FLASH or SHOW them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the coloured

lights above mentioned, have at hand ready for use a lantern with a green glass on the one side and a red glass on the other, to be used as prescribed above.

A steam pilot vessel exclusively employed for the service of pilots licensed or certified by any pilotage authority, or the committee of any pilotage district, when engaged on her station on pilotage duty and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of 8 feet below her white masthead light a red light visible all round the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least 2 miles, and also the coloured side-lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and at anchor, she shall carry, in addition to the lights required for all pilot boats, the red light above mentioned, but not the coloured side-lights.

Pilot vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

Fishing Vessels.

ART. 9.*†—Fishing vessels and fishing boats, when under way and when not required by this Article to carry or show the lights hereinafter specified, shall carry or show the lights prescribed for vessels of their tonnage under way.

(*a*) Open boats, by which it is to be understood boats not protected from the entry of sea water by means of a continuous deck, when engaged in any fishing at night, with outlying tackle extending not more than 150 feet horizontally from the boat into the seaway, shall carry one all-round white light.

Open boats, when fishing at night, with outlying tackle extending more than 150 feet horizontally from the boat into the seaway, shall carry one all-round white light, and in addition, on approaching or being approached by other vessels, shall show a second white light at least 3 feet below the first light and at a horizontal distance of at least 5 feet away from it in the direction in which the outlying tackle is attached.

* This Article does not apply to Chinese or Siamese vessels.

† The expression "Mediterranean Sea" contained in sub-sections (*b*) and (*c*) of this Article includes the Black Sea and the other adjacent inland seas in communication with it.

(b) *Vessels and boats, except open boats as defined in sub-division (a), when fishing with drift nets, shall, so long as the nets are wholly or partly in the water, carry two white lights where they can best be seen. Such lights shall be placed so that the vertical distance between them shall be not less than 6 feet and not more than 15 feet, and so that the horizontal distance between them, measured in a line with the keel, shall be not less than 5 feet and not more than 10 feet. The lower of these two lights shall be in the direction of the nets, and both of them shall be of such a character as to show all round the horizon, and to be visible at a distance of not less than 3 miles.

Within the Mediterranean Sea and the seas bordering the coasts of Japan and Korea† sailing fishing-vessels of less than 20 tons gross tonnage shall not be obliged to carry the lower of these two lights ; should they, however, not carry it, they shall show in the same position (in the direction of the net or gear) a white light, visible at a distance of not less than one sea mile), on the approach of or to other vessels.

(c) Vessels and boats, except open boats as defined in sub-division (a), when line-fishing with their lines out and attached to or hauling their lines and, when not at anchor or stationary within the meaning of sub-division (h), shall carry the same lights as vessels fishing with drift nets. When shooting lines, or fishing with towing lines, they shall carry the lights prescribed for a steam or sailing vessel under way respectively.

Within the Mediterranean Sea, and in the seas bordering the coasts of Japan and Korea,‡ sailing fishing-vessels of less than 20 tons gross tonnage shall not be obliged to carry the lower of these two lights ; should they, however, not carry it, they shall show in the same position (in the direction of the lines) a white light, visible at a distance

* Dutch vessels and boats when engaged in the "kol," or hand-line fishing, will carry the lights prescribed for vessels fishing with drift nets.

† Also, as regards U.S.S.R., vessels, in the seas (excluding the Baltic) bordering the coasts of Russia.

‡ Also, as regards Russian vessels, in the seas (excluding the Baltic) bordering the coasts of Russia.

of not less than 1 sea mile on the approach of or to other vessels.

(*d*) Vessels, when engaged in trawling, by which is meant the dragging of an apparatus along the bottom of the sea—

1. If steam vessels, shall carry in the same position as the white light mentioned in Article 2 (*a*), a tricoloured lantern so constructed and fixed as to show a white light from right ahead to 2 points on each bow, and a green light and a red light over an arc of the horizon from 2 points on each bow to 2 points abaft the beam on the starboard and port sides respectively; and not less than 6 nor more than 12 feet below the tricoloured lantern a white light in a lantern, so constructed as to show a clear, uniform and unbroken light all round the horizon.

2. If sailing vessels, shall carry a white light in a lantern, so constructed as to show a clear, uniform and unbroken light all round the horizon, and shall also, on the approach of or to other vessels, show, where it can best be seen, a white flare-up light or torch in sufficient time to prevent collision.

All lights mentioned in sub-division (*d*), 1 and 2, shall be visible at a distance of at least 2 miles.

(*e*) Oyster dredgers and other vessels fishing with dredge-nets shall carry and show the same lights as trawlers.

(*f*) Fishing-vessels and fishing-boats may at any time use a flare-up light in addition to the lights which they are by this Article required to carry and show, and they may also use working lights.

(*g*) Every fishing-vessel and every fishing-boat under 150 feet in length, when at anchor, shall exhibit a white light visible all round the horizon at a distance of at least 1 mile.

Every fishing-vessel of 150 feet in length or upwards, when at anchor, shall exhibit a white light visible all round the horizon at a distance of at least 1 mile, and shall exhibit a second light as provided for vessels of such length by Article 11.

Should any such vessel, whether under 150 feet in length, or of 150 feet in length or upwards, be attached to a net or other fishing gear, she shall on the approach of other vessels show an additional white light at least 3 feet below the anchor light, and at a horizontal distance of at least 5 feet away from it in the direction of the net or gear.

(*h*) If a vessel or boat when fishing becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall in day-time haul down the day-signal required by sub-division (*k*); at night show the light or lights prescribed for a vessel at anchor; and during fog, mist, falling snow, or heavy rain-storms make the signal prescribed for a vessel at anchor. (See sub-division (*d*), and the last paragraph of Article 15.)

(*i*) In fog, mist, falling snow or heavy rain-storms, drift-net vessels attached to their nets, and vessels when trawling, dredging, or fishing with any kind of dragnet, and vessels line-fishing with their lines out, shall, if of 20 tons gross tonnage or upwards, respectively, at intervals of not more than one minute, make a blast; if steam vessels, with the whistle or syren; and if sailing vessels with the fog-horn; each blast to be followed by ringing the bell. Fishing-vessels and boats of less than 20 tons gross tonnage shall not be obliged to give the above mentioned signals; but if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

(*k*) All vessels or boats fishing with nets or lines or trawls, when under way, shall in day time indicate their occupation to an approaching vessel by displaying a basket or other efficient signal where it can best be seen. If vessels or boats at anchor have their gear out, they shall, on the approach of other vessels, show the same signal on the side on which those vessels can pass.

The vessels required by this Article to carry or show the lights hereinbefore specified shall not be obliged to carry the lights prescribed by Article 4 (*a*), and the last paragraph of Article 11

Stern Light.

ART. 10.—A vessel which is being overtaken by another shall show from her stern to such last-mentioned vessel A WHITE LIGHT or A FLARE-UP LIGHT.

The white light required to be shown by this Article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of 12 points of the compass, viz., for 6 points from right aft on each side of the vessel, so as to be visible at a distance of at least 1 mile. Such light shall be carried as nearly as practicable on the same level as the side-lights.

Vessels at Anchor.

ART. 11.—A vessel UNDER 150 FEET in length, when at anchor, shall carry forward, where it can best be seen, but at a height not exceeding 20 feet above the hull, A WHITE LIGHT in a lantern so constructed as to show a clear, uniform and unbroken light visible all round the horizon at a distance of at least 1 mile.

A vessel of 150 FEET or UPWARDS in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than 20, and not exceeding 40 feet above the hull, one such light, and AT OR NEAR THE STERN of the vessel, and at such a height that it shall not be less than 15 feet lower than the forward light, ANOTHER SUCH LIGHT.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel AGROUND in or near a fairway shall carry the above LIGHT OR LIGHTS and the TWO RED LIGHTS prescribed by Article 4 (*a*).

Signal to Attract Attention.

ART. 12.—Every vessel may, if necessary in order to attract attention, in addition to the lights which she is by these Rules required to carry, show a FLARE-UP LIGHT or use any detonating signal that cannot be mistaken for a distress signal.

Special Recognition Signals.

ART. 13.—Nothing in these Rules shall interfere with the operation of any special Rules made by the Government of any nation with respect to additional STATION AND SIGNAL LIGHTS for two or more ships of war or for vessels sailing under convoy, or with the

exhibition of RECOGNITION SIGNALS adopted by shipowners, which have been authorised by their respective Governments, and duly registered and published.

Steamship Under Sail.

ART. 14.—A steam vessel proceeding under sail only, but having her funnel up, shall carry in daytime, forward, where it can best be seen, ONE BLACK BALL OR SHAPE 2 feet in diameter.

Sound Signals for Fog, etc.

ART 15.—All signals prescribed by this Article for vessels under way shall be given—

1. By "steam vessels" on the whistle or siren.
2. By "sailing vessels and vessels towed" on the fog-horn.

The words "prolonged blast" used in this Article shall mean a blast of from 4 to 6 seconds' duration.

A steam vessel shall be provided with an efficient whistle or siren, sounded by steam or some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog-horn, to be sounded by mechanical means, and also with an efficient bell.* A sailing vessel of 20 tons gross tonnage or upwards shall be provided with a similar fog-horn and bell.

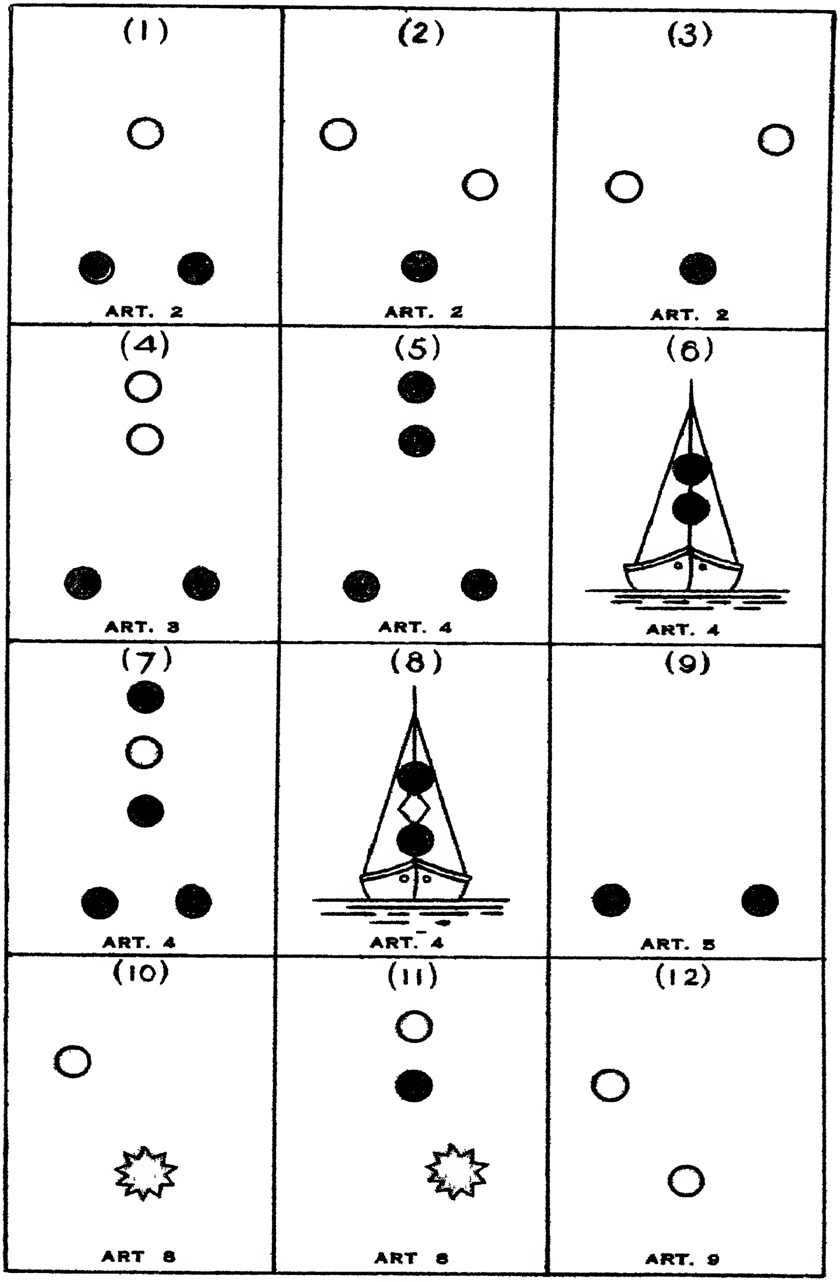
In fog, mist, falling snow, or heavy rain-storms, whether by day or night, the signals described in this Article shall be used as follows, viz. :—

(*a*) A steam vessel having way upon her shall sound, at intervals of not more than 2 minutes, A PROLONGED BLAST.

(*b*) A steam vessel under way, but stopped and having no way upon her, shall sound, at intervals of not more than 2 minutes, TWO PROLONGED BLASTS, with an interval of about 1 second between them.

(*c*) A sailing vessel under way shall sound, at intervals of not more than 1 minute, when on the STARBOARD TACK ONE BLAST, when on the PORT TACK TWO BLASTS in succession, and when with the WIND ABAFT THE BEAM THREE BLASTS in succession.

* In all cases where the Rules require a bell to be used, a drum may be substituted on board Turkish vessels, or a gong where such articles are used on board small sea-going vessels.


(1)
ART. 2
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ART. 9

FIG. 1

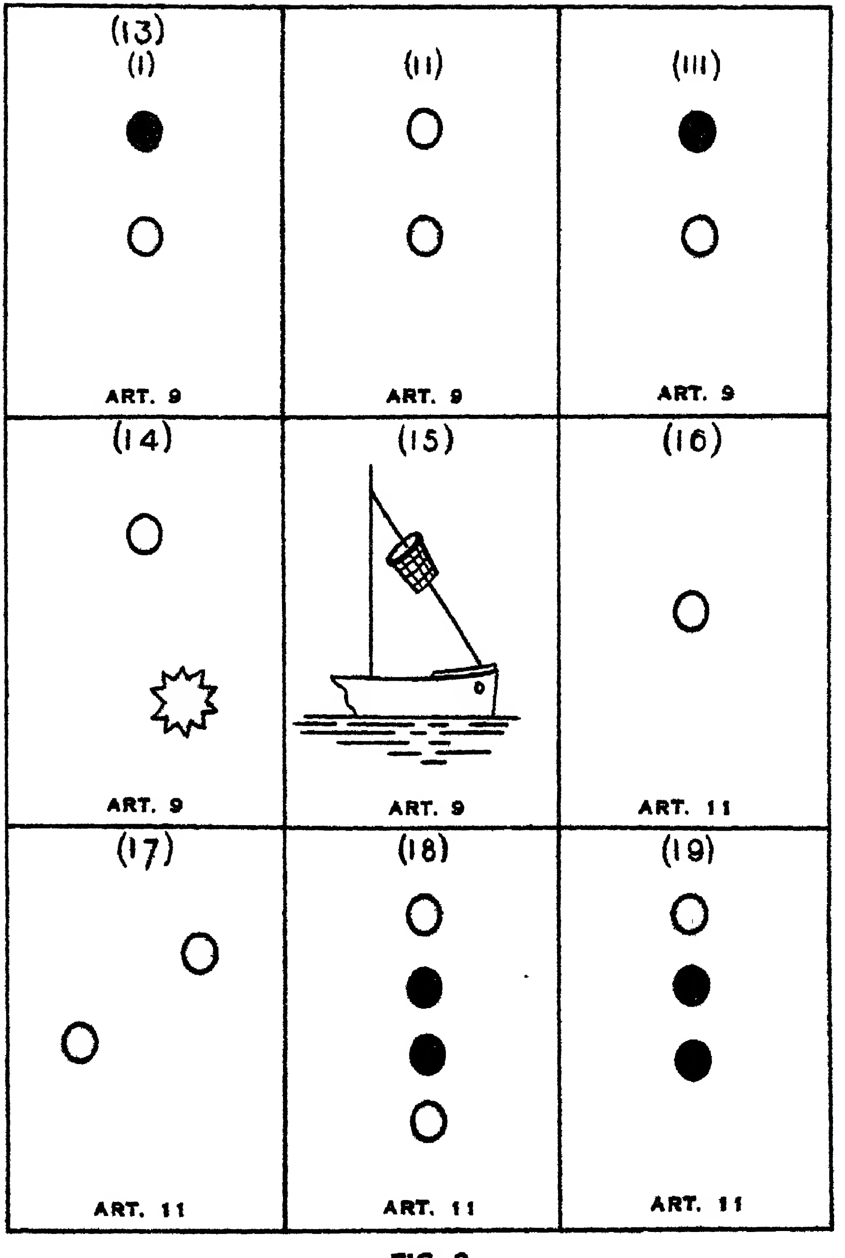
(13)
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FIG. 2

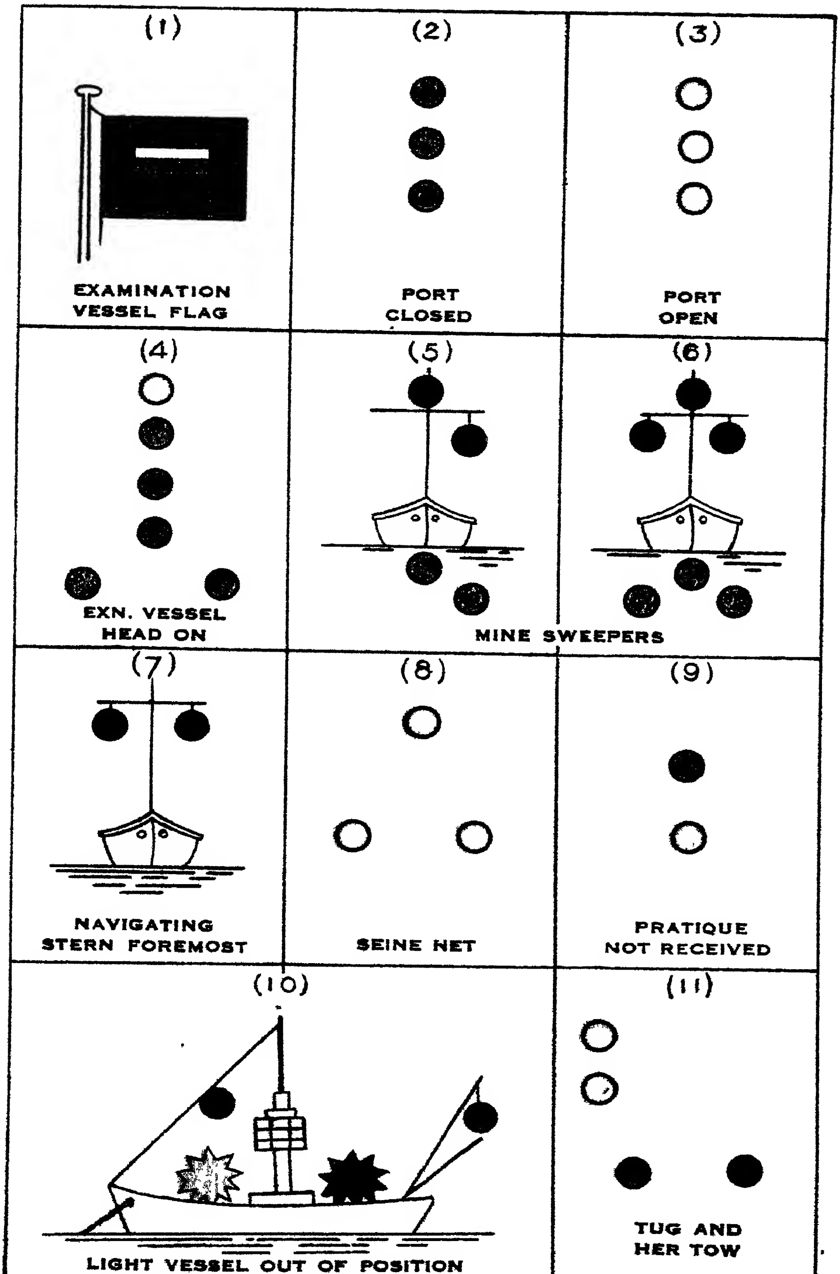

(1)
EXAMINATION VESSEL FLAG
(2)
PORT CLOSED
(3)
PORT OPEN
(4)
EXN. VESSEL HEAD ON
(5)
(6)
MINE SWEEPERS
(7)
NAVIGATING STERN FOREMOST
(8)
SEINE NET
(9)
PRATIQUE NOT RECEIVED
(10)
LIGHT VESSEL OUT OF POSITION
(11)
TUG AND HER TOW

FIG. 3

(*d*) A vessel when at anchor shall, at intervals of not more than 1 minute, ring the bell rapidly for about 5 seconds.

(*e*) A vessel when towing, a vessel employed in laying or in picking up a telegraph cable, and a vessel under way, which is unable to get out of the way of an approaching vessel through being not under command, or unable to manoeuvre as required by these Rules shall, instead of the signals prescribed in sub-divisions (*a*) and (*c*) of this Article, at intervals of not more than two minutes, SOUND THREE BLASTS in succession, viz., one prolonged blast followed by two short blasts. A vessel towed may give this signal and she shall not give any other.

Sailing vessels and boats of less than 20 tons gross tonnage shall not be obliged to give the above-mentioned signals, but if they do not, they shall make some other efficient sound signal at intervals of not more than 1 minute.†

Speed of Ships to be Moderate in Fog, etc.

ART. 16.—Every vessel shall, in fog, mist, falling snow or heavy rain-storms, GO AT A MODERATE SPEED, having careful regard to the existing circumstances and conditions.

A steam vessel hearing, apparently forward of her beam, the fog-signal of a vessel, the position of which is not ascertained, shall, so far as the circumstances of the case admit, STOP HER ENGINES, and then NAVIGATE WITH CAUTION until danger of collision is over.

NAVIGATION LIGHTS.

Significance of Lights and Signals in Diagrams 1 to 19.

The minimum range of visibility of white masthead lights is 5 miles, coloured lights 2 miles, anchor and stern lights (white), 1 mile, drift net and seine net fishing boats' lights (white), 3 miles.

1. ART. 2.—A steam vessel under way, heading towards me, showing masthead lights, also side-lights

† Dutch steam pilot-vessels, when engaged on their station on pilotage duty in fog, mist, falling snow or heavy rain-storms are required to make at intervals of 2 minutes at most 1 long blast with the siren, followed after 1 second by a long blast with the steam whistle, and again after 1 second by a long blast on the siren. When not engaged on their station on pilotage duty, they make the same signals as other steamships.

12. Art. 9.--A fishing vessel with outlying gear extending more than 150 feet, or fishing with nets or lines. The lower light is in the direction of the gear.

13. Art. 9.—A steam trawler. Tri-coloured lamp at masthead showing white sector ahead from 2 points on each bow, green to starboard from 2 points on the bow to 2 points abaft the beam, red to port from 2 points on the bow to 2 points abaft the beam, an all-round white light below the combined lantern ; (i) trawler showing port side ; (ii) trawler head on ; (iii) trawler showing starboard side.

14. Art. 9.—A sailing trawler. White all round light at masthead and a white flare-up when close to other vessels.

Vessels fishing with dredge nets show the same lights as trawlers.

A fishing vessel with gear foul of an obstruction on the bottom becomes a vessel at anchor for the time being.

The anchor lights for a fishing vessel are the same as for other vessels.

15. Art. 9.—A fishing vessel by day showing a ball or basket at the masthead when fishing

A fishing vessel in fog gives in quick succession—**Sail**, sound fog horn and bell ; **Steam**, sound whistle and bell.

16. Art. 10.—Vessel's white stern light showing from right aft to 2 points abaft the beam on either side.

16. Art. 11.—A vessel less than 150 feet at anchor.

17. Art. 11.—A vessel over 150 feet at anchor, the higher light is forward, the lower one at the stern.

Arts. 18 and 19.—A vessel aground in or near a fairway or channel (18) over 150 feet ; (19) less than 150 feet.

A single white light, what may it be ?

(i) A vessel's stern light (ii) An anchor light. (iii) Steamer's masthead light (iv) Sailing trawler's masthead light (v) Sailing pilot vessel's masthead light. (vi) Any small craft. (vii) A distant shore light.

Two white lights vertical, what may they be ?

(i) A vessel at anchor end on. (ii) A steamer's 2 masthead lights end on. (ii) A tug boat's masthead lights. (iv) A vessel fishing with nets or lines end on. (v) A steam trawler end on.

QUESTIONS ON THE RULES CONCERNING LIGHTS, ETC.

Articles 1 to 14.

1. When is a vessel said to be under way?

When she is not at anchor, or made fast to the shore, or aground.

2. During what times must the Rules concerning lights be complied with?

In all weathers from sunset to sunrise; and during such time no other lights which may be mistaken for any Regulation lights must be exhibited.

3. What light or lights are required by the Regulations to be exhibited by vessels at anchor?

If they are under 150 feet in length, one white light forward. If of 150 feet or upwards, two white lights, one forward and one aft. This applies to both steam and sailing vessels.

4. Where must the anchor light be exhibited in a vessel less than 150 feet in length?

Forward, where it can best be seen, and where there is the least chance of obstruction from spars,* etc. It must not be more than 20 feet above the hull.

5. Where must the two anchor lights be shown in vessels of 150 feet and upwards?

One light must be shown forward, not less than 20 and not more than 40 feet above the hull; the other must be at or near the stern and at least 15 feet lower than the forward light.

6. In what direction or directions must the anchor lights show, and at what distance must they be visible?

They must show a clear, uniform and unbroken light, visible all round the horizon at a distance of at least 1 mile.

7. What light or lights must a vessel aground in or near a fairway carry?

The light or lights prescribed for a vessel at anchor, and in addition the two red lights for a vessel not under command.

8. Describe the masthead light for steam vessels.

It must be of such a character and so placed in position that it will show an unbroken white light from right ahead to 2 points abaft

* The forestay well clear of the foremast is the best position, as the masts and funnel being in line will only obstruct it in one direction.

the beam on each side (that is, over an arc of 20 points), and be visible at a distance of at least 5 miles.

9. Where must this masthead light be placed?

On, or in front of, the foremast, or if the vessel has no foremast then in the fore part of the vessel. It must be at least 20 feet above the hull, and if the breadth of the vessel exceeds 20 feet, then at a height not less than such breadth; it need not, however, be placed higher than 40 feet in any case.

10. Does this apply to every steam vessel?

It applies to all steam vessels over 40 tons gross tonnage. Where the tonnage is less than 40 the masthead light may either be as above, or if not as above may be placed on or in front of the funnel at least 9 feet above the hull, showing a bright white light over the same arc visible at least 2 miles.

11. Do steam vessels under way carry an additional masthead light?

A second one may be carried exactly similar to the first. They must be placed in a line with the keel, the forward light at least 15 feet lower than the after one, and the horizontal distance must be greater than the vertical.

12. What advantage is gained by carrying two masthead lights?

Other vessels can see approximately the direction in which the one showing two masthead lights is heading. If approaching end on or nearly end on, the lights would appear vertical or nearly so. If broadside on, the horizontal distance would appear greater than the vertical. Also other vessels would notice if the course was being altered.

13. Describe the side-lights for steamers under way?

A green light on the starboard side, and a red one on the port side. They must be fitted with inboard screens extending at least 3 feet forward from the light, and must be placed and constructed so as to show an unbroken light from right ahead to 2 points abaft the beam, and to be visible at least 2 miles.

14. What lights do sailing ships and vessels being towed carry?

The side-lights as described for steamers, but no masthead light.

15. What other light may vessels show?

A white light at the stern visible 6 points from right aft on each side of the vessel at a distance of 2 miles.

16. When is a steamer engaged in towing required to carry three mast-head lights?

When towing more than one vessel if the length of the tow, measured from the stern of the tug to the stern of the last vessel towed, exceeds 600 feet.

17 What lights are pilot vessels required to carry when on pilotage duty?

A white light at the masthead visible all round for 3 miles, and a flare-up light at intervals not exceeding 10 minutes; also they must have the side-lights ready for use on nearing any other vessel, and show them at short intervals on their respective sides to indicate the direction in which they are heading.

18. What are the special lights for steam pilot vessels on duty?

In addition to the white masthead light required for all pilot vessels they must show a red light 8 feet below it, visible 3 miles all round the horizon, whether at anchor or not. Also, when not at anchor, in addition to the above red and white lights, the side-lights must be carried.

19. Are these lights for steam pilot vessels to be used in British waters only, or are they International?

They are for the use of all nations.

20. Describe the lights and the day signals that vessels employed in laying or picking up a telegraph cable are required to carry.

At night: They must carry in the same position as a steamer's masthead light, and if a steamer, in place of that light, three lights in a vertical line not less than 6 feet apart; the highest and lowest of these lights shall be red, and the middle light white, and each of them must be visible all round the horizon at a distance of at least 2 miles. The side-lights must also be carried if making headway.

By day: They must carry in a vertical line where they can best be seen, and not less than 6 feet apart, three shapes at least 2 feet in diameter, of which the top and bottom must be globular and red, and the middle one diamond in shape and white.

21. Describe the lights and the day signals for a vessel not under command.

At night: They must carry where they can best be seen, at the same height as a steamer's masthead light, and if a steamer, in lieu of that light, two red lights in a vertical line not less than 6 feet apart, and visible all round the horizon at a distance of at least 2 miles. The side-lights must also be carried if making headway.

By day: Two black balls or shapes, each 2 feet in diameter, in a vertical line not less than 6 feet apart, to be placed where they can best be seen.

22 Would you regard these lights and shapes as signals of distress?

No. They must be regarded as signals that the vessel showing them is not under command, and is therefore unable to get out of the way. This is also the case with the lights and shapes shown by vessels engaged in laying or picking up telegraph cables.

23. If you were in a steamship, proceeding under sail only, what signal must you show in the daytime?

A black ball 2 feet in diameter, placed forward where it can best be seen.

24. Under the same conditions, what would you do at night?

Exhibit lights for a sailing ship.

25. If in a steamship your engines break down at night, what change would you make in your lights?

Take down the masthead light or lights; if not under command I would hoist the two red lights, leaving the side-lights in their places if making headway, but taking them in, if not.

26. If you see a single white light, what vessel does that denote the presence of?

It may be a vessel at anchor less than 150 feet in length; the stern light of a vessel I am overtaking; the masthead light of a steamer whose side-lights are not visible; a sailing trawler engaged in trawling; a fishing vessel with her gear foul of some obstruction; or a pilot vessel.

27. You see a flare-up light; what does that indicate?

It may be a pilot vessel on her station; a ship signalling for a pilot; a vessel trying to attract attention (Art. 12); a vessel fishing with nets or trawls.

28. You see two white lights vertical; what vessel may that be?

It may be a steamer approaching end on with two masthead-lights; a steamer engaged in towing with her side-lights not visible; a vessel of 150 feet or upwards at anchor end on; a drift net vessel engaged in fishing end on; or, a steam trawler approaching within 2 points of being end on.

29. What lights are steam trawlers to carry when trawling, and not being stationary in consequence of their gear being foul of a rock or other obstruction?

All steam vessels when trawling must carry the following arrangement of lights:—

A lantern placed in the same position as the masthead light would be, and constructed and fixed so as to show a white light over an arc of 4 points of the horizon, namely, from right ahead to 2 points on each bow, and a red light from 2 points on the port bow to 2 points abaft the port beam, and a green light from 2 points on the starboard bow to 2 points abaft the starboard beam; and, in addition, a white light in a lantern constructed so as to show a clear, uniform, and unbroken light all round the horizon—all these lights to be visible at least 2 miles. This light must be carried lower than the combined lantern, so that the vertical distance between them is not less than 6 nor more than 12 feet.

30. Describe the lights for sailing vessels when engaged in trawling?

Sailing vessels engaged in trawling must carry a white light in a lantern showing a clear, uniform, and unbroken light all round the horizon, visible at least 2 miles. They shall, also, on the approach of or to other vessels, show, where it can best be seen, a white flare-up light or torch in sufficient time to prevent collision.

31. What lights are vessels engaged in drift net fishing required to show?

Vessels and boats (except open boats) engaged in drift net fishing shall carry two white lights where they can best be seen. The vertical distance between them shall be not less than 6 feet and not more than 15 feet, and the horizontal distance, measured in a line with the keel, shall be not less than 5 and not more than 10 feet. The lower of these two lights shall be in the direction of the nets, and both must be visible all round the horizon at a distance of not less than 3 miles.

32. May fishing vessels and open boats use flare-up lights in addition to the above lights?

Yes. They may use flare-up lights at any time, and they may also use working lights.

33. Describe the lights to be shown by open boats engaged in any fishing at night.

They are to carry one all-round white light. If their outlying tackle extends more than 150 feet horizontally from the boat into the

seaway, they are on the approach of or to another vessel, to show a second white light at least 3 feet below the first light, and at a horizontal distance of at least 5 feet away from it in the direction of the outlying tackle.

34. Describe the day signal for fishing vessels?

When under way they shall display a basket where it can best be seen. If at anchor with their gear out they shall, on the approach of other vessels, show the same signal on the side on which those vessels can pass.

35. How can you discern the difference at night between the lights of drift net fishing vessel and those of a vessel at anchor?

Should the vessel be beam on to me a marked difference would be apparent. If she was a drift net fishing vessel her lights would be close together, if she was a vessel at anchor they would have a considerable distance between them. This distinction would be lost if she was end on or nearly end on.

Again, a drift net fishing vessel drifts to leeward of her nets, consequently the lower of her two lights which is in the direction of the nets would be to windward of the higher one. A vessel at anchor riding head to wind would have her higher light to windward. This fact would enable me to distinguish one from the other.

A drift net fishing vessel is also likely to have working lights about the deck while a vessel at anchor is not likely to have them.

A fishing vessel is also likely to show a flare-up light as I approach her.

36. Having decided what was the character of the vessel, in which direction would you pass the lights?

I should pass to leeward of them in both cases. If she was a drift net fishing vessel I should have to go round the higher light. If she was a vessel at anchor I should pass round the lower light.

37. How far may the nets of a drift net fishing vessel extend to windward?

Any distance up to 3 of 4 miles.

38. If unable to pass on the side of the high light of a drift net fisherman what would you do?

I should have to pass on the other side, that is to windward. When bringing the lights in line I should stop the engines and cross the warp at a fair speed. There would then be less danger of fouling it with the propeller than there would be if I kept the engines turning.

QUESTIONS RELATING TO FOG SIGNALS, ETC

Articles 15 and 16.

1. What sound-signalling apparatus are steam vessels required to be provided with?

(i) An efficient steam whistle or siren sounded by steam or some substitute for steam, and so placed that the sound will not be intercepted by any obstruction.

(ii) An efficient fog horn to be sounded by mechanical means.

(iii) An efficient bell.

2. What are sailing vessels of 20 tons gross tonnage and upwards required to have?

A fog horn and bell similar to those required for steamships.

3. When are the signals described in Art. 15 to be used?

In fog, mist, falling snow, or heavy rain storms, whether by day or night.

4. You hear one prolonged blast of a steam whistle or siren; what does that denote?

The presence of a steamship having headway.

5. Suppose you hear two prolonged blasts with an interval of about 1 second between?

It would be a steam vessel under way but stopped, having no headway.

6. How often are steam vessels under way required to repeat their fog signals?

At intervals not exceeding 2 minutes.

7. How often are sailing vessels and vessels at anchor required to give their fog signals?

At intervals not exceeding 1 minute.

8. You hear a prolonged blast followed by two short ones; what does that indicate?

The presence of a vessel towing another; a vessel employed in laying or picking up a telegraph cable; a vessel not under command or unable to manoeuvre in accordance with the Rules; a vessel being towed may also give this signal, but must not give any other.

9. If you were under way in either a sailing ship or steam vessel, and you encountered fog or mist, etc., what would you do in order to comply with the Regulations?

I should at once commence giving the required fog signal, and go at a moderate speed, having careful regard to existing circumstances and conditions. I should also keep an efficient lookout, and bear in mind Art. 29.

10. If the vessel you are in is a steamship, what further precaution are you required to take if you hear apparently forward of your beam the fog signal of another vessel, the position of which is not ascertained?

As far as the circumstances of the case permit I must stop my engines, and then navigate with caution until danger of collision is over.

11. Describe the fog signals to be given by fishing vessels.

If of 20 tons gross tonnage or upwards, they shall at intervals of not more than 1 minute make a blast; if steam vessels with the whistle or siren, and if sailing vessels with the fog horn, each blast to be followed by ringing the bell.

12. What sound signal must sailing vessels and boats of less than 20 tons gross tonnage make?

If they do not give the signal prescribed for larger vessels, they must make some other efficient sound signal at intervals of not more than 1 minute; this applies to both ordinary and fishing vessels.

13. What is the daymark for a vessel at anchor?

A black ball forward at some ports, but it is not international.

14. What is the day signal for a vessel aground in or near a fairway?

Only such signal as the Port Authority may direct.

15. What is the fog signal for a vessel at anchor over 350 feet in length?

Ring the bell forward every minute.

16. What fog signal is given by a vessel being towed?

The same as the towing vessel, viz., a prolonged blast followed by two short blasts.

17. What is the fog signal for a vessel aground in a fairway?

None specified but ring the bell every minute to attract attention.

When being approached by another vessel sound also the Morse letter U (▪ ▪ ▬) meaning "You are standing into danger." See page 625.

CHAPTER X.

STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Articles 17 to 31 Must be Learned Word for Word.

(Begin Now and Memorise One Article at a Time.)

RISK of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist.

Sailing Vessels approaching one another.

ART. 17.—When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, viz.:—

(*a*) A vessel which is running free shall keep out of the way of a vessel which is close-hauled.

(*b*) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(*c*) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(*d*) When both are running free, with the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

(*e*) A vessel which has the wind aft shall keep out of the way of the other vessel.

Steam Vessels meeting end on.

ART. 18.—When two steam vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This Article only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of

collision, and does not apply to two vessels which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are when each of two vessels is end on, or nearly end on, to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own; and, by night, to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply, by day, to cases in which a vessel sees another ahead crossing her own course; or by night to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

Two Steam Vessels Crossing.

ART. 19.—When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

Steam Vessel and Sailing Vessel.

ART. 20.—When a steam vessel and a sailing vessel are proceeding in such directions as to involve risk of collision, the steam vessel shall keep out of the way of the sailing vessel.

Course and Speed.

ART. 21.—Where by any of these Rules one of two vessels is to keep out of the way, the other shall keep her course and speed.

NOTE.—When, in consequence of thick weather or other causes, such vessel finds herself so close that collision cannot be avoided by the action of the giving-way vessel alone, she also shall take such action as will best aid to avert collision. (See Articles 27 and 29.)

Avoid Crossing Ahead.

ART. 22.—Every vessel which is directed by these Rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

Slacken Speed, Stop or Reverse.

ART. 23.—Every steam vessel which is directed by these Rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

Overtaking Vessel.

ART. 24.—Notwithstanding anything contained in these Rules, every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.

> Every vessel coming up with another vessel from any direction more than two points abaft her beam, *i.e.*, in such a position, with reference to the vessel which she is overtaking, that at night she would be unable to see either of that vessel's side-lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these Rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear

As by day the overtaking vessel cannot always know with certainty whether she is forward or abaft this direction from the other vessel, she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

Keep to Starboard Side of Fairway.

ART. 25.—In narrow channels every steam vessel shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such vessel.

Sailing Vessels and Fishing Boats.

ART. 26.—Sailing vessels under way shall keep out of the way of sailing vessels or boats fishing with nets, or lines, or trawls. This Rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fair-way used by vessels other than fishing-vessels or boats.

Avoiding Immediate Danger.

ART. 27.—In obeying and construing these Rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above Rules necessary in order to avoid immediate danger.

Sound Signals for Vessels in Sight of one Another.

ART. 28.—The words "short blast" used in this Article shall mean a blast of about 1 second's duration.

When vessels are in sight of one another, a steam vessel under way, in taking any course authorised or required by these Rules, shall indicate that course by the following signals on her whistle or siren, viz :—

One short blast to mean, "I am directing my course to starboard."

Two short blasts to mean, "I am directing my course to port"

Three short blasts to mean, "My engines are going full speed astern."

No Vessel under any Circumstances to Neglect Proper Precautions.

ART. 29.—Nothing in these Rules shall exonerate any vessel, or the owner, or master, or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper look-out, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Reservation of Rules for Harbours and Inland Navigation.

ART. 30.—Nothing in these Rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbour, river, or inland waters.

Distress Signals.*

ART. 31.—When a vessel is in distress and requires assistance from other vessels or from the shore, the following shall be the signals to be used or displayed by her, either together or separately, *viz.*:—

Note.—The use of any of the above signals, except for the purpose of indicating that a vessel is in distress, and the use of any signals which may be confused with any of the above signals, is prohibited:

* If a master of a vessel uses or displays, or causes or permits any person under his authority to use or display, any of those signals of distress, except in the case of a vessel being in distress, he shall be liable to pay compensation for any labour undertaken, risk incurred, or loss sustained in consequence of that signal having been supposed to be a signal of distress, and that compensation may without prejudice to any other remedy, be recovered in the same manner in which salvage is recoverable. (Merchant Shipping Act, 1894, section 434 (2).)

In the daytime—

1. A gun or other explosive signal fired at intervals of about a minute;

2. The International Code signal of distress;

3. * The distant signal, consisting of a square flag, having either above or below it a ball or anything resembling a ball;

4. A continuous sounding with any fog-signal apparatus;

5. The international distress signal made by radiotelegraphy or radiotelephony, or by any other distant signalling method.

At night—

1. A gun or other explosive signal fired at intervals of about a minute;

2. Flames on the vessel (as from a burning tar-barrel, oil-barrel, etc.);

3. Rockets or shells, throwing stars of any colour or description, fired one at a time, at short intervals;

4. A continuous sounding with any fog-signal apparatus;

5. The international distress signal made by radiotelegraphy or radiotelephony, or by any other distant signalling method.

The use of any of the above signals, except for the purpose of indicating that a vessel is in distress, and the use of any signals which may be confused with any of the above signals, is prohibited.

THE STEERING AND SAILING RULES

Articles 17 to 27.

These Articles form the most difficult part of the Regulations for beginners. A knowledge of the preceding ones depends in a great measure upon the memory, but the Steering and Sailing Rules appeal more to your intelligence and knowledge of seamanship. They therefore demand special attention in order that you may be able to apply them readily and promptly whenever occasion to do so arises.

Risk of Collision.—The preliminary paragraph on Risk of Collision is of great importance, as it shows how you may ascertain—when circumstances permit—if risk of collision exists between approaching vessels.

*A further distress signal is provided in the "International Code of Signals." It is a distant signal consisting of a cone point upwards, having either above or below it a ball, or anything resembling a ball. This signal has not been sanctioned by Order in Council under the provisions of section 434 of the Merchant Shipping Act, 1894

To be practical we must not expect to be able, under the varying conditions arising at sea, to treat the Rules with mathematical exactness. We can, however, establish one or two general principles which, properly appreciated, will afford valuable help to beginners. A diagram and explanation will show the truth of the preliminary paragraph.

Suppose A and B to be two vessels approaching each other in the directions $A\,C$ and $B\,C$ respectively. Their courses cross at C, and if they both reach this point at the same time a collision must occur. If they are proceeding so as to reach the point C together their speeds must be proportional to their respective distances from C. Thus, in the diagram, A being the farther vessel from the collision point, her speed must

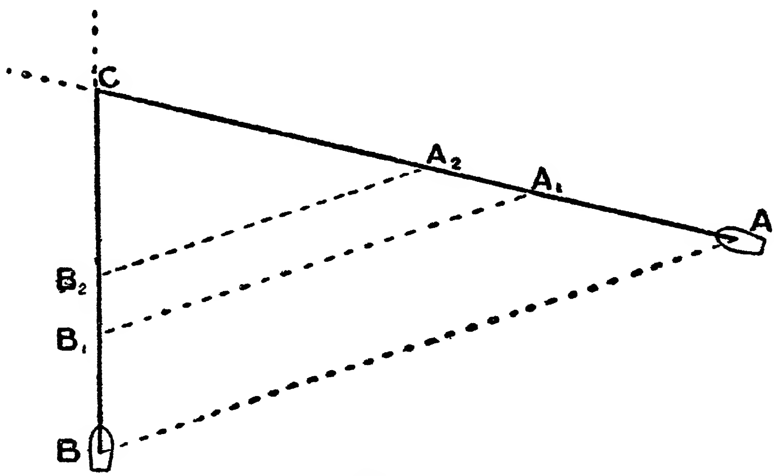


Fig 1.

be proportionally greater than that of B to cause her to reach C at the same time. Assuming that this is the case; when A has sailed one-third of her distance from C and is at A_1, B will also have sailed one-third of her distance from C and will be at B_1; also when A has completed half her distance from C and is at A_2, B will have covered half her distance from C and will be at B_2, and so on.

If lines are drawn joining these corresponding positions, it will be seen that they are parallel, thus showing that the bearings of the two vessels from each other would not appreciably alter if they were approaching in such a manner as to involve risk of collision.

If you see both side-lights of another vessel in any direction, your own vessel is in the act of passing the collision point. Also it is clear

that if you see a side-light of another vessel ahead, the positions are reversed, and the other vessel is in the act of crossing. Unless the vessels are near each other, there is very little risk of collision in these two cases, but care should be taken in the vessel having the other ahead not to deviate from her course towards the direction in which the other vessel is heading.

Again, if the bearing of a light does not change appreciably, it not only shows that risk of collision exists, but it also gives a hint as to the probable direction in which the other vessel is heading. It may be stated as a general rule that the broader a light bears on the bow th

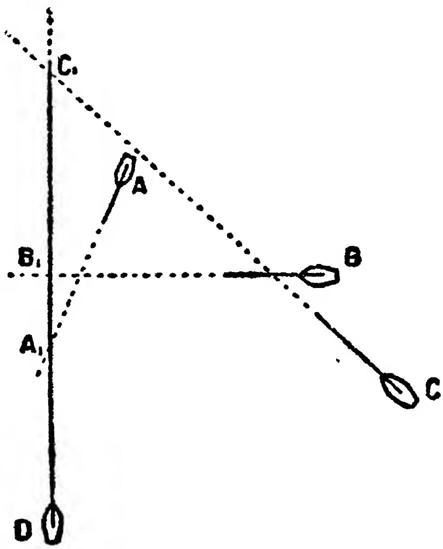


Fig. 2.

farther away must be the point of collision. Suppose you see, about a point on the bow, the side-light of another vessel crossing, and let us assume, for the purpose of illustration, that both vessels are going 10 miles an hour, that they are 2 miles apart, and are proceeding in such directions as to involve risk of collision. The point of collision would be about 1 mile away, and would be reached (assuming that each vessel kept her course and speed) in about 6 minutes. Had the light been about 4 points on the bow, the collision point would have been about 1½ miles away, and would have been reached in about 9 minutes.

If it had been 6 points on the bow, the point of collision would have been $2\frac{1}{2}$ miles away, and have been reached in 15 minutes. This is illustrated in the annexed diagram.

A, *B*, and *C* are vessels 1 point, 4 points, and 6 points on the bow respectively. A_1, B_1, and C_1 the respective points of collision with *D*, assuming each one to be going at the same speed as *D*.

Of course at sea you never know the speed of the other vessel, but the foregoing is useful, and points out that when it is your duty to keep out of the way of another vessel the more nearly she is ahead of you the greater is the need for prompt action. Also, when a light bears nearly ahead, and it is your duty to "keep out," it is hardly necessary to wait to see if the bearing alters, as a slight change of your course in the right direction will convert the position into one of safety.

So far no notice has been taken of the lengths of vessels. This is an important factor, and one which must be considered. Its importance rapidly increases as vessels near each other. In order to avoid collision, the whole length of one vessel must pass clear of the crossing point before the stem of the other reaches it; therefore, not only must the bearing change but it must change *appreciably*, otherwise risk of collision must be deemed to exist. You must use your own judgment as to what constitutes an appreciable change of bearing.

Notice also the words, "when circumstances permit," as cases may arise where it may be advisable and necessary for the giving-way vessel to act immediately and not to wait to see if the bearing alters.

Avoiding Collision.—Articles 21, 22 and 23 deal more particularly with the avoidance of collision. Article 22, and also common sense, require that the vessel which has to keep out of the way shall, if circumstances permit, avoid crossing ahead of the other—the latter being required (by Article 21) to keep her course and speed except in special cases. (See Note, Art. 21.)

Refer to Figure 3 which is intended to represent four ships on converging courses and heading for a common collision point. Assume yourself to be in ships *A*, *B*, *C* and *D* in turn with only one of the other three vessels in sight, that is, cover any two of the vessels with your hand and state what you would do if there was risk of collision with the third vessel, assuming there is room to manoeuvre.

In Ship *A*.— (1) Keep clear of *B* (Art. 19). I would alter course to starboard and go under his stern, or, if very close I would slow down or stop and let him

pass ahead of me (Article 23), or, alter course to port.
(2) Alter course to starboard for *C* (Article 18).
(3) Stand on for *D*.

In Ship *B*—(1) Keep clear of *C*.
(2) Stand on for *D*
(3) Stand on for *A*.

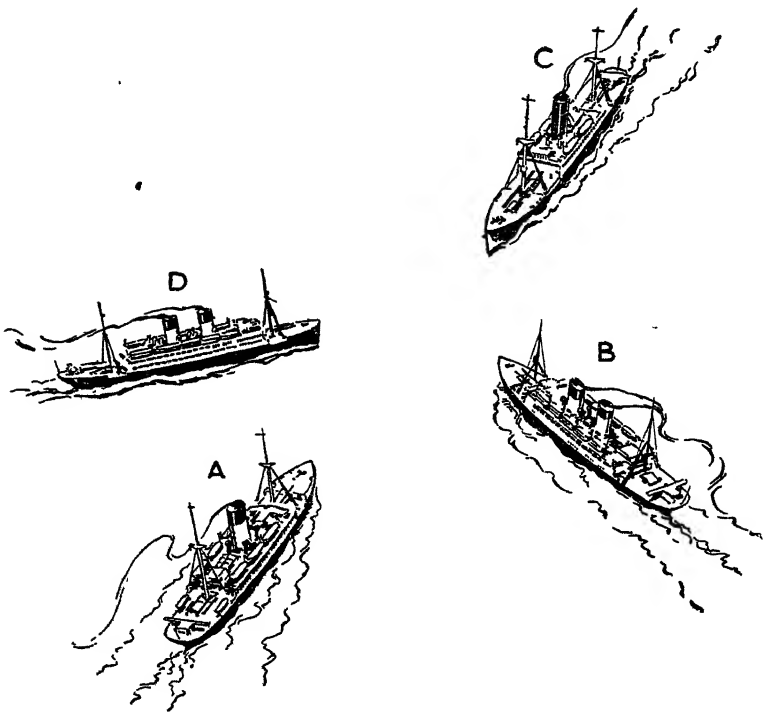


Fig. 3.

In Ship *C*—(1) Keep clear of *D*.
(2) Alter course to starboard for *A*
(3) Stand on for *B*.

In Ship *D*—(1) Keep clear of *A*.
(2) Keep clear of *B*.
(3) Stand on for *C*

Articles 18 and 19.

You are in a steam vessel, what would you do in each of the following cases assuming there is risk of collision?

1. You see the side-lights and masthead lights of another steam vessel ahead?

Alter my course to starboard (Art. 18), because we are meeting end on, and give one short blast on the whistle (Art. 28).

2. Red light and masthead lights of a steamship on your starboard bow?

Keep out of her way (Art. 19) I would alter course to starboard to go under her stern (Art. 22) and give one short blast (Art. 28) If too close to go under her stern I would alter course to port, and give two short blasts. If dangerously close I would stop the engines and reverse (Art. 23).

3 A steamship's green and masthead lights on your port bow?

Stand on (Art. 19), and keep my course and speed (Art. 21).

4 A steam vessel's red and masthead lights about 4 points on your starboard bow, and as you are watching the bearing of the red light, a green light appears about 2 points on the bow; what would you do, assuming that the bearing of the red light is not changing appreciably?

The green light is that of a passing vessel. I should wait until the green light had altered its bearing to about 6 points or so on the bow, and then keep out of the way of the red. If I found it necessary I should slacken speed or stop my engines.

Questions on the remaining Steering and Sailing Rules.

Articles 20 to 27.

1. If a steam vessel and a sailing vessel are approaching each other so as to involve risk of collision, which vessel is required to keep out of the way?

The steam vessel. (Art. 20.)

2. Are there any special cases where the sailing vessel would have to keep out of the way of the steam vessel?

Yes. If the sailing vessel was overtaking the steamer; or if the steamer was engaged in laying, picking up, or repairing a telegraph cable; or if the steamer was not under command.

3 Where, by the Rules, one of two vessels is required to keep out of the way, what is the other required to do?

To keep her course and speed. (Art. 21.)

4 Is there any qualification or exception to this?

Yes. The note attached to Article 21 says that when, in consequence of thick weather or other causes, two vessels are so close that collision cannot be avoided by the action of the giving-way vessel alone, the other shall take such action as will best aid in averting a collision; also

Article 27 says due regard must be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the Rules necessary in order to avoid immediate danger; also

Article 29 says, nothing in these Rules shall exonerate any vessel, or the owner, or master, or crew thereof, from the consequences arising from the neglect of any precaution required by the ordinary practice of seamen or the special circumstances of the case.

5 Suppose a vessel is approaching you so as to involve risk of collision, and that it is your duty to "keep out of the way," do the Regulations specify what action you must take?

No It is left to myself to decide what action must be taken to avoid collision, but the Rules state that if circumstances admit I must avoid crossing ahead of the other vessel (Art. 22); also, if I am in a steamer I must if necessary slacken speed, or stop, or reverse. (Art. 23.)

Note that there is one exception in this case When two steam vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other. (Art. 18.)

6. Are sailing vessels under way required to keep out of the way of sailing vessels and boats engaged in fishing?

Yes. They must keep out of the way of sailing vessels or boats fishing with nets or lines or trawls. (Art. 26.*)

7. When one vessel is overtaking another, which is required to keep out of the way?

The overtaking vessel. (Art. 24.)

*Note that this Article does not require sailing vessels to keep clear of *steam* fishing vessels. They are, however, hampered by their trawl and unable to manœuvre in the same way as ordinary steamers. It is the *ordinary practice of seamen* for sailing vessels to keep out of their way. They should, therefore, always do so. (Article 29.)

8. Is there any exception to this rule?

No. For Article 24 says, "Notwithstanding anything contained in these Rules, every vessel overtaking any other shall keep out of the way of the overtaken vessel."

9. Are you required to depart from the Steering and Sailing Rules in any particular case?

Yes. But only when special circumstances render a departure necessary in order to avoid immediate danger. (Art. 27.)

10 You are in a steamer and you see two other steam vessels, one on your port bow, the other on your starboard bow, and both are approaching so as to involve risk of collision; what would you do?

I should keep out of the way of the one on my starboard side; the other vessel has to keep out of my way. (Art. 19.)

11. But would you not then be departing from the Rule which requires you to keep your course and speed for the one on your port bow?

Yes; but I should consider this a special case in which, by Article 27, I was required to depart from that Rule in order to avoid collision with the one on the starboard bow.

12. When a steam vessel takes any course authorised or required by the Regulations, must she indicate that course to the other vessel or vessels?

Yes (Art. 28), but only when the vessels are in sight of each other.

13. How must she indicate what course she is taking?

By signals on the whistle or siren.

1 short blast means—"I am directing my course to starboard."

2 short blasts mean—"I am directing my course to port."

3 short blasts mean—"My engines are going full speed astern."

14. Has a steamer towing another vessel any right of way not usually allowed to other vessels?

No. She must follow the ordinary Rule of the Road for steamers.

15. In what waters or seas are vessels required to follow the Regulations?

Upon the high seas and in all waters connected therewith navigable by seagoing vessels, but nothing in the Rules shall interfere with the operation of a special rule duly made by local authority relative to the navigation of any harbour, river, or inland waters. (Preliminary to Articles.)

16. A green light overhauls you on your port side and then attempts to cross ahead. What would you do?

As she is the overtaking vessel she must keep clear of me until she is finally past and clear. (Art. 24). I must keep my course and speed. (Art. 21.) At the same time I must observe the footnote to Article 21, and if she gets too near me to avoid collision by her own action I should also take action as would best help her to do so. Probably that would be "full speed astern," 3 short blasts. Look out for anything that might be coming up behind me.

17. You are in a steam vessel and you sight the red light of a sailing vessel on your port bow. What would you do?

We are passing ships and will most likely go clear of each other. If she was to windward of me and was in ballast, or if it was blowing hard, she might be sagging down to leeward towards me. I should watch her bearing carefully and if it did not change appreciably should alter my course to starboard to get out of her way. Should give her 1 short blast. (*See* Arts. 27, 28, and 29.)

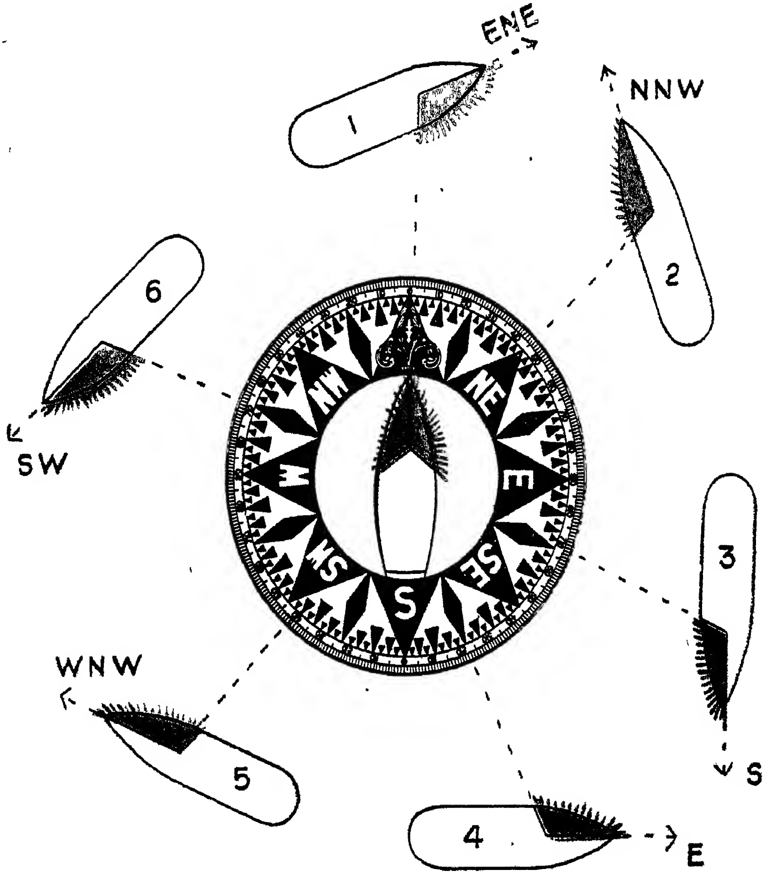


Diagram 1.

A vessel's side-light just shut out on a given bearing, how is she heading?

TO FIND OUT HOW ANOTHER VESSEL IS HEADING.

A vessel's side-lights are screened to show the light from right ahead to 2 points abaft her beam (See further note on screening of side-lights, page 256.)

When the side-light of another vessel is cut off from view, or is just coming into sight, it indicates that the observer is bearing 2 points abaft **her** beam. From this information the direction in which the other vessel was heading at the moment can be ascertained as follows:—A Red light just being shut out will indicate that the vessel carrying it was heading 6 Points to the Left of its bearing, because red is the left hand light.

A Green light being just shut out will indicate that the vessel carrying it was heading 6 Points to the Right of its bearing, because green is the right hand light.

The rule has nothing whatever to do with the direction the observer's vessel is heading, unless the bearing of the other ship is given as so many points on the bow, when, of course, he must know how his vessel is heading in order to get the bearing of the light.

In **Diagram 1** the observer must imagine himself to be in the centre of the compass, which represents the centre of his horizon, and that the side-light of each of the vessels Nos. 1 to 6 is just being shut out on the respective bearings as indicated, it is required to know how each vessel was heading.

1. Green light shut out when bearing North?
   Six points to right of the bearing—E.N.E.
2. Red light shut out when bearing N.E.?
   Six points to left of the bearing—N.N.W.
3. Green light shut out on an E.S.E. bearing?
   She is heading South.
4. Red light disappears on a S.S.E. bearing?
   She is heading East.
5. Green light disappears on a S.W. bearing?
   She is heading W.N.W.
6. Red light shut out when bearing W.N.W.?
   She is heading S.W.

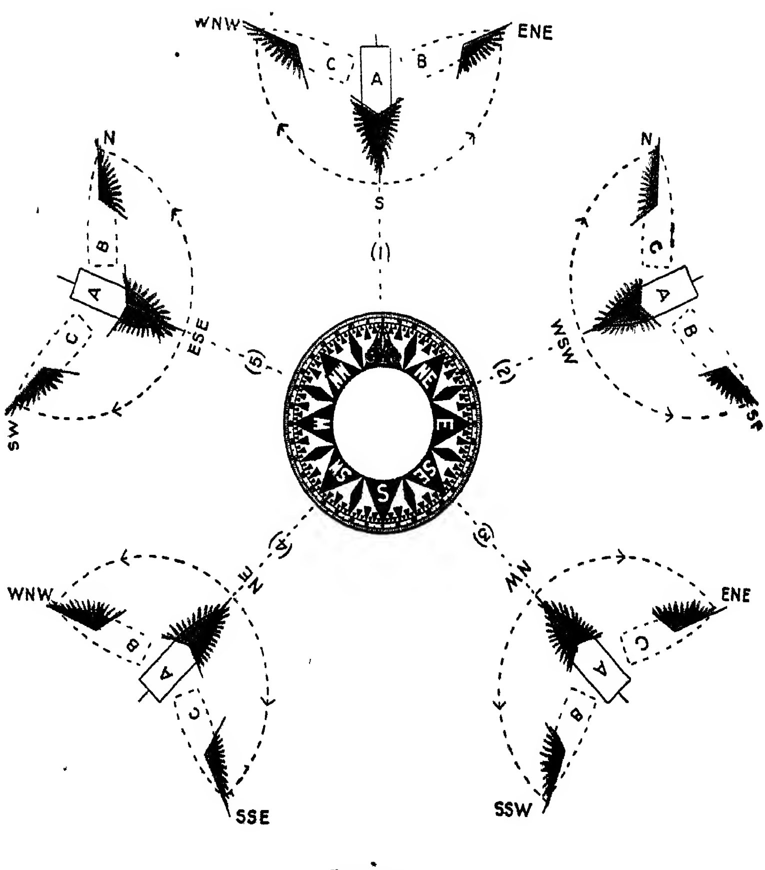


Diagram 2

The bearing of a side-light on a given bearing, between what points of the compass may the vessel be heading?

The observer is supposed to be standing at the centre of the compass, shown in **Diagram 2,** which is also the centre of his horizon, the points of the compass radiating outwards towards the sea horizon. There are five examples given and it is required to know, in each case, between what points the other vessel is heading when one of her side-lights is sighted on a given bearing. Let us discuss each example separately.

1. *A*. Both side-lights bearing North? The vessel can only be heading South.

   B Green light bearing North. When the vessel turns her head to port from position *A* she shuts out her red light; the observer will see only her green light until she has swung through 10 points, that is, when she heads E.N.E., for then the observer will be 2 points abaft her beam and the green light will then disappear.

   Rule.—Count 6 points to **Starboard** of the bearing for a **Green light,** or, 6 points to **Port** of the bearing for a **Red** light, and the vessel will be heading somewhere between that direction and the **Bearing Reversed** nearly.

   The green light was bearing North? The vessel is heading between E.N.E. and almost South.

   C Red light bearing North? The vessel is heading between W.N.W. and almost South.

   When the vessel's head turns to starboard from position *A* the green light is shut out and the observer will see only her **red** light until she has swung through 10 points, that is, when she is heading W.N.W., then it will disappear as the observer will then be 2 points abaft her beam.

2 *A*. Both side-lights bearing E.N.E.? The vessel is heading W.S.W.

   B. Green light bearing E.N.E.? The vessel is heading between S.E. and W.S.W. nearly.

   C. Red light bearing E.N.E.? The vessel is heading between North and W.S.W. nearly.

3. *A*. Both side-lights bearing S.E.? The vessel is heading N.W. Turn the book round and look outwards from the centre of the compass towards the light.

   B. Green light bearing S.E.? She is heading between S.S.W. and N.W. nearly.

   C. Red light bearing S.E.? She is heading between E.N.E. and N.W.

4. *A*. Both side-lights bearing S.W.? She is heading N.E.
   B. Green light bearing S.W.? She is heading between W.N.W and N.E.
   C. Red light bearing S.W.? She is heading between S.S.E. and N.E.
5. *A*. Both lights bearing W N.W.? She is heading E.S E.
   B. Green light bearing W.N.W.? She is heading between North and E.S.E.
   C. Red light bearing W.N.W.? She is heading between S.W. and E.S.E.

The angle of parallax subtended by the two masthead lights of a steamship gives a good idea of the direction she is heading. When one light is vertically over the other she is approaching end on; when the lower light is to the right of the higher one she is crossing over to starboard and when the lower light is to the left of the higher one she is crossing over to port.

A square-rigged vessel cannot head closer to the direction of the wind than 6 points, that is to say, the wind is 6 points on her starboard bow when she is on the starboard tack and 6 points on her port bow when she is on the port tack, so that there is always an arc of the horizon of 12 points on which she cannot make headway.

A sailing vessel in fog gives **One blast** when on the **Starboard** tack; **Two Blasts** when on the **Port** tack, and **Three blasts** when she has the wind **Abaft the Beam.** She gives the close-hauled signal when the wind is exactly abeam, and when changing from one tack to the other she continues to give the fog signal for the last tack she was on until she has headway on her new tack.

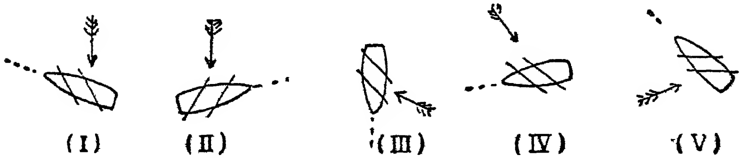


Fig. 4.

Examples—in fog—

(i) Wind North, a sailing vessel giving 1 blast, how is she heading? W.N.W.

(ii) Wind North, a sailing vessel giving 2 blasts; how is she heading? E.N.E.

Wind North, a sailing vessel giving 3 blasts; how is she heading? From East to West by way of South.

(iii) Wind E.S.E., sailing vessel giving 2 blasts? She is heading South.

(iv) Wind N.W. by N., sailing vessel giving 1 blast? She is heading W. by S.

(v) Wind W.S.W., sailing vessel giving 2 blasts? She is heading N.W.

Wind W.N.W.. sailing vessel giving 3 blasts? She is heading anywhere between N.N.E. and S.S.W. by way of East.

Exercise I.

How is the other vessel heading in the following examples for exercise? These should be worked out with the help of a compass card.

1. A green side-light shut out when bearing (i) N.W., (ii) W.S.W., (iii) S. by W., (iv) S.E., (v) E.N.E., (vi) N.E. by N.

2. A red side-light shut out when bearing (i) N. by E., (ii) E. by S., (iii) South, (iv) S.S.W., (v) West, (vi) N.W. by N.

3. Heading N.N.E., a red side-light disappears when bearing 2 points abaft the port beam?

4. Heading S.E., a red side-light disappears when bearing 3 points on the starboard bow?

5. Heading E. by N., a green light disappears when bearing 2 points on the port bow?

6. Heading S.W. by S., a red light disappears when bearing 2 points abaft the starboard beam?

Exercise II.

Between what 10 points may the other vessel be heading in the following exercises.

1. A green side-light bearing (i) N.E., (ii) E.S.E., (iii) S.S.W., (iv) N.W. by N.?

2. A red side-light bearing (i) N.N.E., (ii) S.S.E., (iii) W.S.W., (iv) N.N.W.?

3. Heading N.W., a green side-light is sighted 2 points on the starboard bow, between what points may she be heading?

4. Heading S. by W., a green side-light is sighted 4 points on the port bow, between what points may she be heading?

5. Heading W.N.W., a red side-light bears 2 points on the port bow, between what points may she be heading?

6. Heading S.E. by S., a red side-light is sighted 4 points on the starboard bow, between what points may she be heading?

Exercise III.

You are in a steamship; state between what points the sailing vessels in the following examples may be heading, making due allowance for the direction of the wind.

	Side-light	Bearing	Wind.
1.	Green	S.W.	South
2.	,,	E S.E.	N.W.
3.	,,	E N.E.	S.S.E.
4.	Red	S.E.	North
5.	,,	S.S.W.	S.E
6.	,,	W.S.W.	N.W.

7. You are heading North The wind is right aft. You see a green light ahead. How is that ship steering?

8. You are heading North, with a S.E. wind. You see a green light ahead. How is that ship steering?

9. You are heading South. Wind North. You see a red light ahead. How is the other ship heading?

10. You are heading South. Wind N.E. You see a red light ahead. How is the other ship heading?

11. You are heading N.E. with the wind West. You see a green light ahead. Between what points is that vessel steering?

12. You are heading N.N.E. with the wind South. You see a green light 2 points on starboard bow. How is the other vessel steering?

13. You are heading S.E. with the wind right ahead, and you see a sailing vessel's red light 4 points on your starboard bow. Between what points is she steering?

Answers—Exercise I.

1. (i) N.N.E., (ii) N.W., (iii) W. by S., (iv) S.S.W., (v) S.E., (vi) E. by S.

2. (i) N.W. by W., (ii) N.E. by N., (iii) E.S.E., (iv) S.E., (v) S.S.W. (vi) W. by S.

3. S.S.W. 4. E. by S. 5. S.E. by E. 6. W. by S.

Exercise II.

1. (i) E.S E. to S.W. nearly, (ii) South to W.N.W. nearly, (iii) West to N.N.E. nearly, (iv) N.E. by N. to S.E. by S. nearly.

2. (i) N.W. to S.S.W. nearly, (ii) E. to N.N.W. nearly, (iii) South to E.N.E nearly, (iv) West to S.S.E. nearly.

3. N.E. to S.S.E.

4. S.W. by S. to N.W. by N.

5. S.S.W. to E.

6. S.E. by E. to N. by E.

Exercise III.

1. W.N.W. to N.E. Free to port, wind aft or free to starboard.

2. W.S.W. to South. Free to starboard.

3. S.W. to W.S.W. Close-hauled to port.

4. E.N.E. Closed-hauled to port.

5. E.N.E. to N.N.E. Close-hauled to starboard or slightly free to starboard.

6. South to E.N.E. Free to port, wind aft or free to starboard.

7. E.N.E. to E.S.E. She may have the wind from 2 points before the starboard beam to 2 points abaft the beam.

8. E.N.E. Close-hauled to starboard.

9. E.N.E. to E.S.E. She could have the wind from 2 points abaft her port beam to 2 points before her beam.

10. E.S.E. Close-hauled to port.

11. E.S.E. to S.S.W. Free to starboard or close-hauled to starboard.

12. E.S.E. Close-hauled to starboard.

13. E.N.E. to N. Free or close-hauled to starboard.

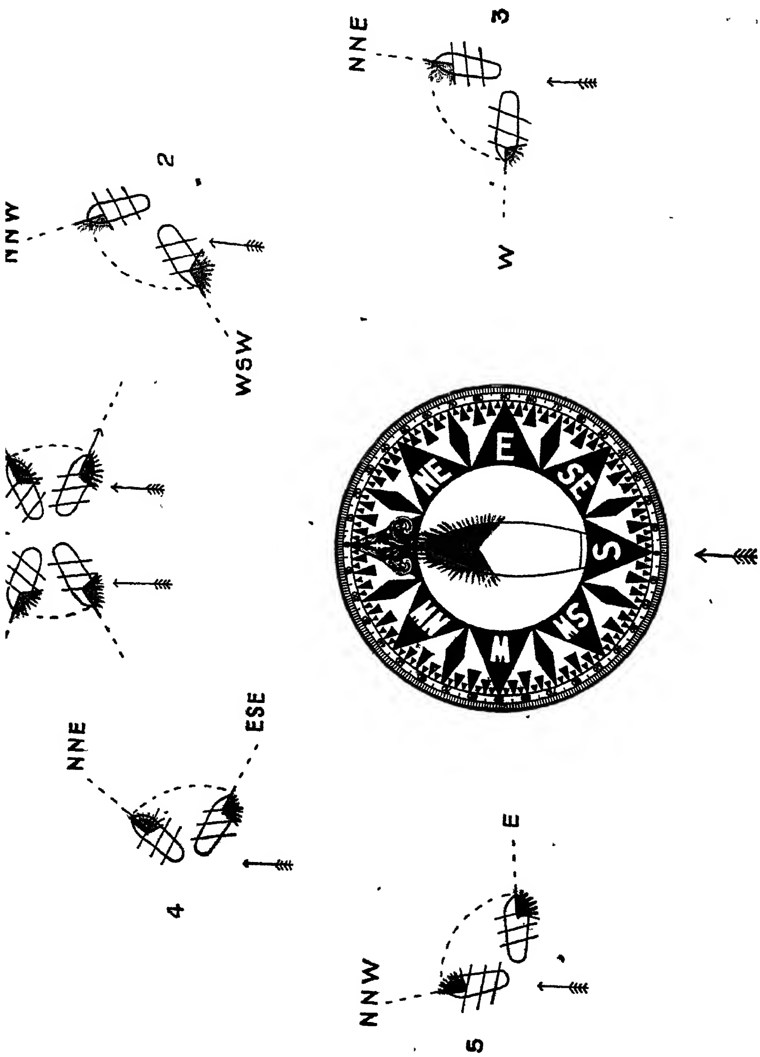


Diagram 3.

In a steamship heading North, wind South, what would you do for each of the sailing ships?
State between what points she may be heading and how she is carrying the wind.

Diagram 3 represents a steamship heading North with the wind from South, right aft. Discuss the respective lights of the sailing vessels on the bearings as indicated, how the vessels may be heading, how they are carrying the wind and what action the steamship should take if there were risk of collision.

1. The wind being from South the prohibited courses for a sailing vessel lie between E.S.E. and W.S.W., that is 6 points on each side of the wind.

The green light ahead indicates a sailing vessel heading between E.N.E. and E.S.E. She cannot lie closer to the wind than 6 points, viz., E.S.E. She may be close-hauled to starboard, or she may have the wind a little abaft her beam depending on how she is heading.

The red light ahead indicates a vessel heading between W.N.W. and W.S.W. She may be close-hauled to port, or slightly free with the wind a little abaft her port beam.

2. The red light 4 points on my starboard bow indicates a sailing vessel heading between W.S.W. and N.N.W. She is either close-hauled to port, or free to port.

3. The red light on my starboard beam indicates a vessel heading between West and N.N.W., she is free to port.

4. The green light 4 points on my port bow indicates a vessel heading between E.S.E. and N.N.E., she cannot lie closer to the wind than E.S.E. She is either close-hauled to starboard, or free to starboard.

5. The green light on my port beam is that of a sailing vessel heading between East and N.N.W., free to starboard.

If the lights keep on the same bearing there is risk of collision. I would give 1 blast and alter course to starboard and pass under the stern of the red lights on my starboard bow, and for the green lights on my port bow I would alter course to port and give 2 blasts.

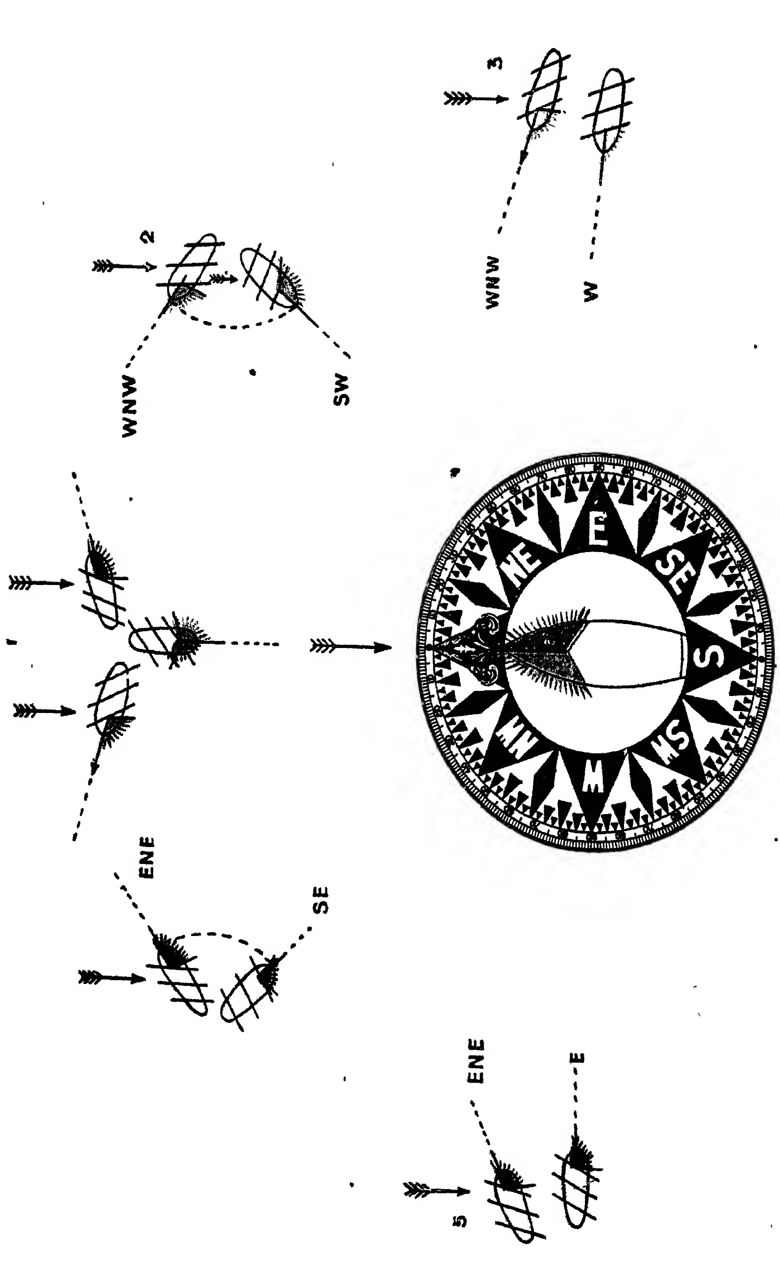


Diagram 4.

In a steamship heading North, wind right ahead, what would you do for each of the sailing ships? State between what points she may be heading and how she is carrying the wind.

Diagram 4 represents a steamship heading North with the wind from North, right ahead, and a sailing vessel ahead showing both her side-lights, or her green light, or her red light. We wish to discuss between what points she may be heading, how she is carrying the wind, and what action the steamship should take if there were risk of collision.

1. When the wind is North the prohibited courses for a sailing vessel lie between E.N.E. and W.N.W.

When she is showing both side-lights she is heading South with the wind right aft.

When showing her green light only she is heading somewhere between E.N.E. and South. She is either free with the wind on her port quarter, or close-hauled to port.

When showing her red light only she is heading somewhere between W.N.W. and South, and is either free with the wind on her starboard side, or close-hauled to starboard.

2. Her red light 4 points on my starboard bow would indicate that she is heading between S.W. and W.N.W., close-hauled to starboard, or she may have the wind a little abaft her starboard beam.

3. Her red light on my starboard beam would indicate she is heading between West and W.N.W., close-hauled to port.

4. Her green light 4 points on the port bow indicates she is heading between S.E. and E.N.E. so that she is either close-hauled to port, or running with the wind free a little abaft her port beam.

5. Her green light on my port beam indicates she is heading between East and E.N.E., close-hauled to port.

When a light keeps on the same bearing there is risk of collision, and should this be imminent I would alter course to starboard for a red light on my starboard bow and give 1 blast. Alter course to port for a green light on my port bow and give 2 blasts.

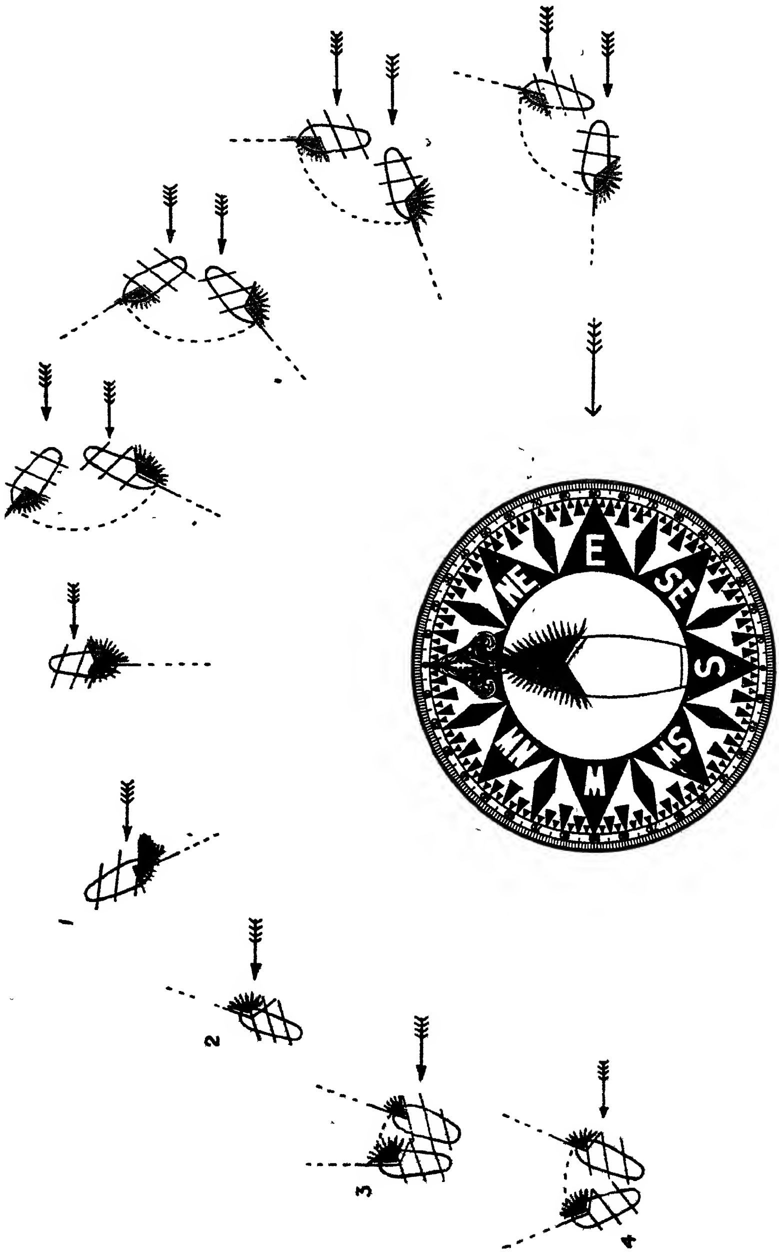


Diagram 5.

Wind on starboard beam. Steamship meeting a sailing vessel.

Diagram 5.—You are in a steamship heading North, wind East, discuss how the respective sailing vessels in the diagram showing you their red or green side-lights may be carrying the wind.

When the wind is East the prohibited courses for sailing vessels lie between N.N E. and S.S.E., 6 points on either side of the direction of the wind.

The sailing vessels showing a red light on any bearing on the starboard bow are not restricted and can sail in any direction within the full 10-point arc of their red light. They are running free with the wind either on their port quarter, right aft, or on their starboard quarter as indicated by the wind arrows.

A vessel showing her green light on my port bow cannot take advantage of the full 10-point arc of her green light as she would then be heading within 6 points of the wind.

1. The vessel showing both her red and green lights 2 points on my port bow can only be heading S S.E., close-hauled on the port tack.

2. The vessel showing her green light 4 points on my port bow can only be heading N.N.E., close-hauled on the starboard tack.

3. The vessel showing her green light 6 points on my port bow can only head between N.N.E. and N., close-hauled on the starboard tack.

4. The vessel showing her green light on my port beam can only be heading between N.N.E. and N.N.W. She may be close-hauled on the starboard tack, or have the wind a little abaft her starboard beam.

If a sailing vessel's red light on my starboard bow does not alter its bearing there is risk of collision. I would alter course to starboard and give 1 short blast.

If a sailing vessel's green light on my port bow does not alter its bearing there is risk of collision. In this example we are, however, on slightly converging courses and approaching each other slowly. I could give 2 blasts, alter course to port and pass under her stern; or if I were close to her and passing I could give 1 blast, alter course to starboard and when finally passed and clear resume my course.

I would alter course to starboard for the red and green lights ahead and also for the red and green lights 2 points on my port bow.

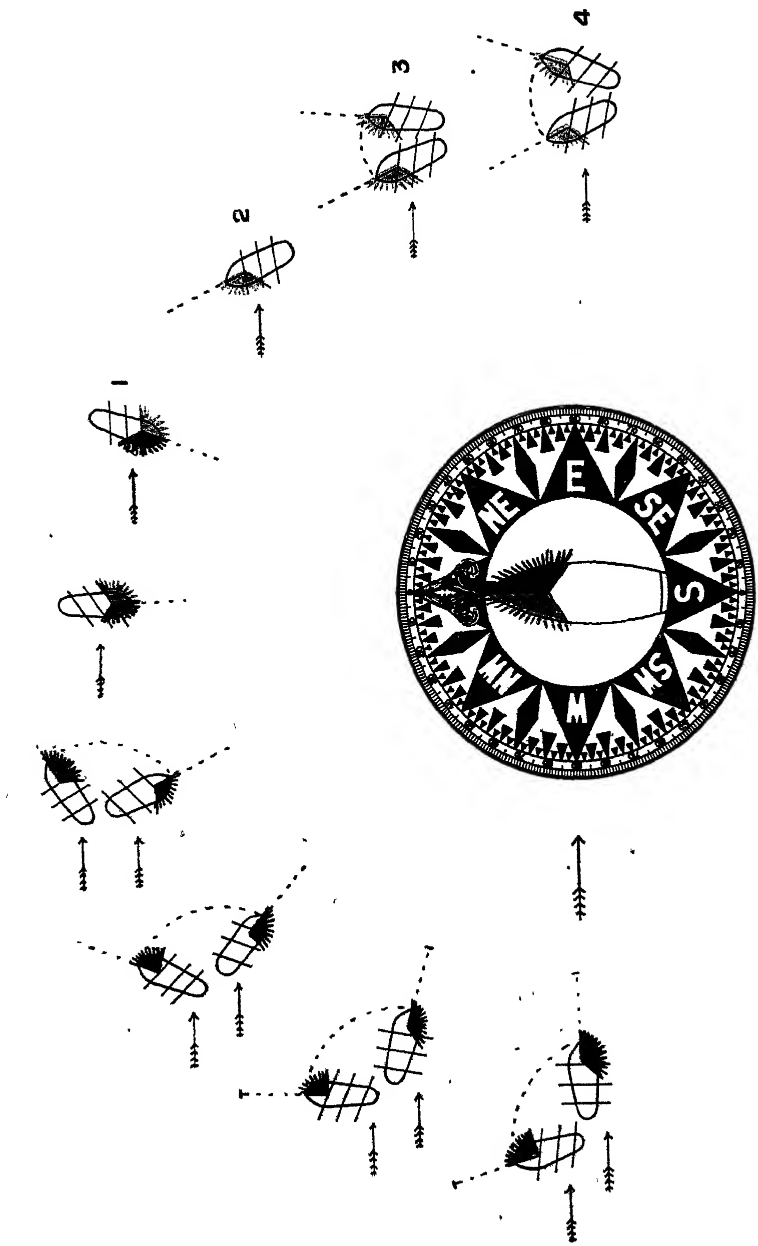


Diagram 6.

Wind on port beam. Steamship meeting a sailing vessel.

Diagram 6.—You are in a ship heading North, wind West, discuss how the respective sailing vessels in the diagram showing their red or green side-lights may be carrying the wind.

When the wind is West the prohibited courses for sailing vessels lie between N.N.W. and S.S.W.

The sailing vessels showing a green light on any bearing on my port bow are not restricted and can be sailing in any direction within the full 10-point arc of their green light. They are running free with the wind either on their port quarter, right aft, or on their starboard quarter as indicated by the wind arrows.

A vessel showing her red light on my starboard bow cannot take advantage of the full 10-point arc of her red light as she would then be heading within 6 points of the wind.

1. The vessel showing both her red and green lights 2 points on my starboard bow can only be heading S.S.W., close-hauled on the starboard tack.

2. A vessel showing her red light 4 points on my starboard bow can only be heading N.N.W., close-hauled on the port tack.

3. A vessel showing her red light 6 points on my starboard bow can only head between N.N.W. and North, close-hauled on the port tack.

4. A vessel showing her red light on my starboard beam can only head between N.N.W. and N.N.E. She may be close-hauled on the port tack, or have the wind a little abaft her port beam.

Assuming any one of the sailing vessels' lights shown in the diagram to keep on the same bearing, there would be risk of collision and I have to keep clear.

I would give 2 blasts and alter course to port for a green light on my port bow.

I would alter course to starboard and give 1 blast, for the red and green lights right ahead; and also for the red and green 2 points on my starboard bow. The vessels showing the red lights broad on the bow are heading more or less in the same direction and we are closing in slowly. Before risk of collision is imminent I could give 1 blast, alter course to starboard and go under their stern; or if I were passing very close I could give 2 blasts, alter course to port and pass ahead of them, resuming my course when I was finally passed and clear.

NOTES RELATING TO THE ARTICLES.

Extracts from Merchant Shipping Act.

If any damage to person or property arises from the non-observance by any ship of any of the Collision Regulations, the damage shall be deemed to have been occasioned by the wilful default of the person in charge of the deck of the ship at the time, unless it is shown, to the satisfaction of the Court, that the circumstances of the case made a departure from the Regulation necessary.

Where in a case of collision it is proved to the Court before whom the case is tried, that any of the Collision Regulations have been infringed, the ship by which the regulation has been infringed shall be deemed to be in fault, unless it is shown to the satisfaction of the Court that the circumstances of the case made departure from the Regulation necessary.

Duty of Master in case of Collision.

In every case of collision between two vessels it shall be the duty of the master or person in charge of each vessel, if, and so far as he can do so without danger to his own vessel, crew, and passengers (if any),

(*a*) To render the other vessel, her master, crew, and passengers (if any) such assistance as may be practicable and may be necessary to save them from any danger caused by the collision, and to stay by the other vessel until he has ascertained that she has no need of further assistance; and also

(*b*) To give to the master or person in charge of the other vessel the name of his own vessel and of the port to which she belongs, and also the names of the ports from which she comes and to which she is bound.

If the master or person in charge of a vessel fails to comply with this section, and no reasonable cause for such failure is shown, the collision shall, in the absence of proof to the contrary, be deemed to have been caused by his wrongful act, neglect, or default; and if he is a certificated officer an enquiry into his conduct may be held, and his certificate cancelled or suspended.

In every case of collision, in which it is practicable to do so, the master of every ship shall, immediately after the occurrence, cause a statement thereof, and of the circumstances under which the same occurred, to be entered in the official log book, and the entry shall be signed by the master and also by the mate or one of the crew.

If the master fails to comply with this section he shall, for each offence, be liable to a fine not exceeding £20.

Report of Accidents to Steamships.

When a steamship has sustained or caused any accident occasioning loss of life or any serious injury to any person, or has received any material damage affecting her seaworthiness or her efficiency, either in her hull or machinery, the owner or master shall, within 24 hours after the happening of the accident or damage, or as soon thereafter as possible, transmit to the Board of Trade by letter, signed by the owner or master, a report of the accident or damage and of the probable occasion thereof, stating the name of the ship, official number, port of registry, and the place where she is. Penalty for non-compliance, a fine not exceeding £50.

Penalty for not exhibiting lights, a fine not exceeding £100.

CHAPTER XI.

NOTICES TO MARINERS.

THESE Notices are issued by the Admiralty for the information of mariners in foreign-going vessels.

(*a*) Daily Notices of an urgent nature or of major importance.

(*b*) Weekly Notices containing information which has become available during the previous week for the correction of Admiralty Charts and Sailing Directions.

(*c*) A Quarterly Edition gives in collated form the information published in the weekly editions during the previous quarter.

Notices for home-trade and fishing vessels are also issued daily and weekly.

4. On 1st January of each year the Board of Trade publishes and distributes, for the use of foreign-going, home-trade, and fishing vessels, a book containing general information for the guidance of Mariners, *e.g.*, notices regarding distress signals, life-saving, various special signals, etc. Copies of the daily, weekly, and quarterly editions may be obtained at any Mercantile Marine Office.

These Notices are applicable to the navigation of British waters and some of the more permanent are, in effect, supplementary to the International Regulations for Preventing Collisions at Sea. We give here a synopsis of the more important Regulations issued within recent years up to 1936.

Closing of Ports.—When a port is closed by order of the Admiralty 3 red balls vertical are displayed from a prominent position by day, and at night 3 red lights vertical. When those signals are shown by an Examination vessel they are additional to her usual navigation lights.

Vessels entering the harbour proceed according to instructions; if no instructions are given they must go to the Examination Anchorage marked on the chart or keep out to sea.

Three white lights vertical are shown when the port is open. Vessels are requested to have ready at hand 2 all-round red lanterns and 2 all-round white lanterns to be displayed as directed.

The examination vessels on duty fly a special flag, white and red horizontal surrounded by a blue border.

Mine Sweeping Operations.—Mine-sweepers show a black ball at the foremast-head and a black ball at the yardarm on the side on which

it is dangerous to pass. When black balls are shown at each yardarm it is dangerous to pass on either side within a distance of at least 900 yards.

Green lights are shown at night in place of the black balls by day.

Single Vessels Approaching Squadrons.—A vessel approaching a squadron of warships should avoid going amongst them. If unable to keep out of their way the ordinary Regulations for preventing collision apply.

Warning Signals to Denote Presence of Submarines.—The vessel escorting the submarines displays a square red flag. She should be given a wide berth and, if it is necessary to pass close to the escort, vessels should proceed at slow speed and keep a sharp lookout for periscopes.

Aircraft at Anchor show the same lights as surface craft and also wing tip white lights when the span exceeds 150 feet.

AIRCRAFT.

Information with regard to Distress Signals by Day and Night.—Mariners and others are notified that when any aircraft is in distress and requires assistance, the following shall be the signals displayed by her, either together or separately:—

I. The International Signal "S O S" by means of Visual or Wireless Telegraphy or in the case of Radio Telephony the spoken word "Mayday."

II. The International Code Signal of Distress indicated by N.C.

III. The Distant Signal consisting of a square flag having above or below it a ball or anything resembling a ball.

IV. A continuous sounding with any sound apparatus.

V. A signal consisting of a succession of white pyrotechnical lights, fired at short intervals.

VI. A white flare from which at intervals of about 3 seconds a white light is ejected into the air.

In the event of a distress call being received from an aircraft in distress over the English Channel, the position of the aircraft will be fixed by directional wireless from the appropriate D.F. stations and a warning will then be broadcast to shipping by North Foreland wireless station giving the necessary particulars.—December, 1927.

SALVAGE OF TORPEDOES.

Instructions for the Recovery and Safe Handling of Torpedoes lost from H.M. Ships.

1. A torpedo is a cigar-shaped object, varying from 15 to 22 feet long, and from 14 to 21 inches in diameter. It has a more or less pointed nose and tapering tail. At the after end of the tail are fins, rudders, and two screw propellers, one immediately abaft the other. It is generally made entirely of steel. The weight of torpedoes varies from under half a ton to a ton and a quarter.

2. **A Torpedo used in Peace Exercises never contains any Explosive Material.** A calcium light is used in the nose to assist in recovery; it is quite harmless and may be left to burn out.

3. A person who does not understand the mechanism of a torpedo should be careful to avoid touching any small levers which project from a slit in the upper part of the torpedo a little abaft the middle of the body of the torpedo. It is possible under certain conditions, that the screw propellers of a derelict torpedo may be caused to revolve rapidly if these levers are moved. Fingers, hands and body should be kept clear of the propellers at all times in case they should be accidentally started, when a nasty cut may result.

4. A torpedo may be found floating, sometimes lying flat along the surface of the water, and sometimes with its tail submerged and its nose only showing above the water.

5. It should be taken in tow by means of a wire or stout rope (at least 3 ins.) with a running eye (or noose) in the end.

6. If the tail of the torpedo can be reached, the running eye should be passed over the screw propellers and fins and bowsed taut around the small part of the tail.

7. If the tail is submerged, the running eye should be dropped over the nose and allowed to fall down until it grips the small part of the tail in the same way.

8. The torpedo should then be towed tail first.

9. Should it be desired to hoist a torpedo inboard it should be slung with a good wire strop around the centre of the torpedo; the balancing point is about in line with those projections on each side which are rather less than half way from nose to tail. Before hoisting, lines should be made fast to the tail and nose and these lines should be attended so as to keep the torpedo level while hoisting, and prevent it

slipping through the strop. When the torpedo is inboard, it should be lashed down to the deck, or on wooden chocks to keep it off the deck, and the screw propellers should be well lashed together to prevent any chance of their starting to revolve.

10. A torpedo when recovered should be handed over to the most convenient Coastguard or Naval Authority, with a statement of where it was found, and any details of importance.

11. A reward of at least £5 is offered for a lost torpedo after it has been missing for a day.

12. In case of damage to gear or loss of any kind incurred in the recovery of a torpedo, a written statement should be handed over with the torpedo, and any reasonable increase in the reward will then be considered by the Admiralty.

SIGNALS FROM H.M. SHIPS.

When a man-of-war desires to communicate with a merchant vessel, she will hoist the Code Pendant in a conspicuous position and keep it flying during the whole time the signal is being made.

PILOTS.

Caution—In view of the danger and difficulty often attending the shipping and discharging of pilots in exposed positions, the attention of masters is directed to the necessity of observing every precaution in manoeuvring their ships when a pilot is either boarding or leaving, especially in cases where a vessel is in ballast and strong winds are prevailing. The master or officer in charge of the bridge should take care to satisfy himself, on dropping the pilot, that the latter is well clear of the ship and particularly of the counter before the propeller is moved.

LIGHTVESSELS IN THE UNITED KINGDOM.

Regulations.—The following Regulations have been established respecting the several lightvessels on the coasts of the United Kingdom, viz.:—

A white light is exhibited from the forestay of each lightvessel, at a height of 6 feet above the rail, for the purpose of showing in which direction the vessel is riding, when at her station.

Light Vessels under the jurisdiction of the Corporation of Trinity House when not in their correct position as a safe guide to shipping will continue the present practice of not showing their characteristic light or sounding their fog signal, and *on and after the* 1*st July*, 1931, will exhibit the following special signals, viz.:—

By Day.—The characteristic topmark will be struck if practicable. Two large black globes or shapes will be exhibited one forward and one aft. The International Code Signal **"P.C."** will be flown.

By Night—Two red lights will be exhibited one forward and one aft. Two flares, one red and the other white, will be shown simultaneously at least every quarter of an hour or if the use of flares be impracticable a red light and a white light will be displayed simultaneously.

Watch buoys are can buoys painted red, with "Watch" preceded by lightvessel's name in white letters. They are moored near the vessel to mark position.

If from any cause the lightvessel be unable to exhibit her usual lights whilst at her station, the riding light only will be shown.

The mouths of fog horns, which are not fitted to distribute the sound equally all round, are pointed to windward.

At lightvessels where a hand horn is used, the intervals will be shortened as vessels approach, and should a vessel come dangerously close the sound will be continuous until she has passed.

When, from any of the lightvessels or from Trinity House Lighthouse a vessel is seen standing into danger, the two signal flags **J D** of the International Code, "You are standing into danger," will be hoisted and kept flying until answered. In addition to the above flag signal the lightvessel will fire a gun or socket signal, and repeat it at short intervals until observed by the vessel.

It should be remembered that lightvessels are liable to be withdrawn for repairs, without notice, and in some cases not replaced by relief vessels.

COLLISIONS WITH LIGHTVESSELS.

Caution.—In consequence of lightvessels being from time to time run into and seriously damaged by vessels navigating in their vicinity, the Corporation of Trinity House deem it desirable to warn mariners that when passing a lightvessel, and particularly when attempting to cross her bows, they should make due allowance for the set of the tide and take every other precaution desirable in the circumstances in order to avoid striking the lightvessel. Attention is specially directed to the 666th section of the Merchant Shipping Act, 1894, which provides that anybody wilfully or negligently running foul of any lightvessel or buoy shall, in addition to the expense of making good any damage so occasioned, incur a penalty of £50.

VESSELS NAVIGATED STERN FOREMOST.

Such vessels display two balls, each 2 feet in diameter, carried at the ends of a horizontal jackyard on the mast or, if the vessel has more than one mast, on the main or after-mast. The jackyard will be placed in a thwartship direction, at least 6 feet higher than the funnel top, and will project at least 4 feet on either side of the mast, so that the distance between the centres of the two balls will be at least 8 feet.

Bye-laws giving effect to this arrangement have been made for the ports of Dover, Ramsgate, Holyhead, Larne and Belfast.—July 23, 1930.

SUBMARINE CABLES.

Should a submarine cable be lifted to the surface by a vessel heaving up anchor she should pass the end of a 5-inch manila rope (do not use wire) under the cable, make the end fast inboard, haul the rope tight and hang the cable on the bight of the rope, then lower the anchor clear of the cable which can then be slipped. The fouling of a cable together with the position as accurately as possible should be reported the nearest cable station.

Skippers of trawlers are urged to exercise care when trawling near telegraph cables, and if a cable is fouled great caution should be exercised in attempting to clear it. It is advisable to sacrifice the gear rather than to exert force in freeing it. Compensation for loss of gear is made on a sworn declaration being made and upheld.

SEINE NET FISHING BOATS SHOW.

By Day.—One black ball or basket in the forepart of the vessel and a black cone or triangle, apex upwards, at the mizzen yardarm. Pass her on the clear yardarm side.

By Night.—Three white lights in a triangle, apex upwards, from the yardarm on the side from which the gear is leading. She exhibits her side-lights when running out the gear, but no side-lights when hauling it in.

Sound Signal.—Seine net vessels give 4 blasts, 3 long and 1 short, on the whistle (— — — ▪) when approached by other vessels. In fog, seine net vessels give the same signal as other fishing vessels. These special lights and signals are given to warn vessels off their nets as the warps and gear may be as much as a square mile in extent.

When flares are displayed by a fleet of fishing vessels on being approached by another vessel they are warning her off their nets. It is necessary to give them a wide berth as a train of nets may extend over an area of one square mile.

SYSTEM OF BUOYAGE (1947)

Adopted by the leading Pilotage Authorities

The mariner when approaching the coast must determine his position on the chart and note the direction of the MAIN STREAM OF FLOOD TIDE.

The term **Starboard Hand** shall denote that side which would be on the RIGHT HAND of the mariner either going with the main stream of flood or entering a harbour, river, or estuary from seaward, the term **Port Hand** shall denote the LEFT HAND of the mariner under the same circumstances

Buoys are named **Conical Can** or **Spherical** according to their shape above water. **Conical** buoys are kept on the starboard hand, **Can** buoys on the port hand when going in the direction of the flood stream. **Spherical** buoys mark the ends of MIDDLE GROUNDS. See Fig. 4

Buoys having a TALL CENTRAL STRUCTURE on a broad base are called **Pillar** buoys and, like other special buoys such as Bell buoys, Gas buoys, Automatic signalling buoys, etc., shall be placed to mark special positions either on the coast or in approaches to harbours.

Wreck buoys in the open sea, or in the approaches to a harbour or estuary, shall be coloured GREEN, with the word "Wreck" painted in WHITE letters on them. Submarine telegraph cable buoys are painted BLACK with the word "Telegraph" in WHITE letters on them.

Starboard Hand Marks.—Conical buoys. Black (B) or Black and White Chequers (B.W. Cheq.). Topmarks (if any)—Black Cone (point upwards) or, for purposes of differentiation except at entrance to a channel, a Black Diamond. Light (if any)—White showing 1 or 3 or 5 flashes

Port Hand Marks.—Can buoys. Red (R) or Red and White Chequers (R.W. Cheq.) Topmarks (if any)—Red Can or, for purposes of differentiation, a Red "T" except at entrance to a channel. Light (if any)—White showing 2 or 4 or 6 flashes, or Red flashes up to 4.

Middle Ground Marks.—Spherical buoys Red and White Horizontal Bands (R.W.H.B) where main channel is to the RIGHT or the channels

are of equal importance Black and White Horizontal Bands (B.W.H.B where the main channel is to the LEFT. Topmarks (if any)—(a) Main channel to RIGHT. Outer End, Red Can; Inner End, Red "T". (b Main channel to LEFT: Outer End, Black Cone: Inner End, Black Diamond. (c) Channels of equal importance· Outer End, Red Sphere Inner End, Red St Georges' Cross Lights (if any)—As far as possible lights will be distinctive, but no colours will be used other than white or red, and neither colour will be such as to lead to uncertainty as to the side on which the mark shall be passed.

Mid Channel Marks.—Shape to be distinctive and different from the principal characteristic shapes (conical, can or spherical). Coloured Black and White Vertical Stripes (B W.V S.) or Red and White Vertical Stripes (R W V S).

Topmarks (if any)—Distinctive shape other than cone, can or sphere Light (if any)—Different from neighbouring lights or marks at side of channel

Isolated Danger Marks.—Spherical, with wide Black and Red Horizontal Bands separated by a narrow White Band Topmarks (if any)—Sphere painted Black or Red or half Black and half Red horizontally. Light (if any)—White or Red with flashing character

Landfall Marks.—Shape in accordance with channel marking painted Black and White or Red and White Vertical Stripes. Light (if any)—Flashing character.

The Conical, Can and Spherical shaped buoys are retained in the new system, but the distinctive colourings and topmarks are changed.

Instead of starboard hand buoys (Conical) being painted in one colour only they are now to be painted all black, or black and white chequers. The Port Hand buoys (Can), formerly single or parti-coloured, are now to be all red, or red and white chequers. The Spherical buoys at the ends of a Middle Ground, instead of the distinctive white and black horizontal bands as formerly, are now to be painted red and white, or black and white horizontal bands.

Distinctive Topmarks, when fitted, are to be shaped as a cone, diamond, can, sphere, St. George's Cross or a "T". A black cone or a black diamond on starboard hand buoys. A Red Can or a Red "T" on Port Hand buoys. The R.W.H.B. Middle Ground buoys indicating that the main channel is to the right may have a Red Can on the outer

end and a Red "T" on the inner end But should the channels to right and left be of equal importance then the Topmark will be a Red sphere on the outer end and a Red St George's Cross on the inner end

Special marks and colourings to distinguish mid channels, isolated dangers and landfall marks are as described previously.

Buoys and Beacons

Wrecks have occurred through undue reliance on buoys and floating beacons always being maintained in their exact position

They should be regarded simply as aids to navigation and not as infallible marks, especially when placed in exposed positions.

The lights shown by gas buoys cannot be implicitly relied on as, if occulting, the apparatus may get out of order, or the light may be altogether extinguished.

WRECK MARKING SIGNALS.

To be passed on the mariner's starboard hand when going in the direction of the flood stream.

By Day.—Three green balls (3) vertical at the yardarm, 6 feet apart, the lowest to be at least 9 feet above the hull.

By Night.—Three green lights (3) in place of the balls.

In Fog.—Three strokes (3) on a deep toned bell every 30 seconds.

Wreck Buoy.—Green conical giving 3 green flashes every 10 or 15 seconds if lighted. The chart abbreviation would be, Con. Gn. Fl (3) ev. 15 sec.

To be passed on the mariner's port hand.

By Day.—Two green balls (2) vertical at the yardarm, 6 feet apart, the lower one to be at least 15 feet above the hull.

By Night.—Two green lights (2) in place of the balls.

In Fog.—Two strokes (2) on a deep toned bell every 30 seconds.

Wreck Buoy.—A green can buoy giving two green flashes every 10 seconds if lighted. Chart abbreviation, Can Gn. Fl. (2) ev. 10 sec.

To be passed on either side.

By Day.—Two green balls (2) vertical at each yardarm, 6 feet apart, the horizontal distance between them from 15 to 25 feet.

By Night.—Four green lights (4) in place of the 4 balls.

In Fog.—Four strokes (4) on a deep toned bell.

Wreck Buoy.—Green spherical giving one green flash (1) every 5 or 6 seconds if lighted. Chart abbreviation, Sph. Gn. Fl. (1) ev. 5 sec.

Wreck marking vessels should be given a wide berth when passing them?

INFORMATION RE FOG SIGNALS.

The following information in regard to fog signals is promulgated for the guidance of mariners:

1. Fog signals are heard at greatly varying distances.
2. Under certain conditions of atmosphere, when an air fog signal is a combination of high and low tones one of the notes may be inaudible.
3. There are occasionally areas around a fog signal in which it is wholly inaudible.
4. A fog may exist a short distance from a station and not be observable from it, so that the signal may not be sounded.
5. Some fog signals cannot be started at a moment's notice after signs of fog have been observed.

Mariners are therefore warned that fog signals cannot be implicitly relied upon and that *the practice of sounding should never be* neglected. Particular attention should be given to placing "Look-out men" in positions in which the noises in the ship are least likely to interfere with the hearing of the sound of an air fog signal; as experience shows that, though such a signal may not be heard from the deck or bridge when the engines are moving, it may be heard when the ship is stopped, or from a quiet position. It may sometimes be heard from aloft though not on deck.

There are three means adopted for signalling in fog:—

(*a*) By air sound signals comprising (1) *Diaphone,* (2) *Siren,* (3) *Reed,* (4) *Nautophone,* (5) *Gun,* (6) *Explosive,* (7) *Bell* or *Gong,* and (8) *Whistle*;

(*b*) By submarine sound signals produced either by (9) an *Oscillator* or (10) *Bell*; and

(*c*) By Wireless Telegraphy.

I. Air Fog Signals.

The *Diaphone* (1), *Siren* (2), and *Reed* (3) are all three compressed air instruments fitted with horns for distributing the sound.

The *Diaphone* emits a powerful low-tone note terminating with a

sharp descending note termed the "grunt," the *Siren* a medium powered note, either high or low or a combination of the two, and the *Reed* a high note of less power. Reeds may be hand-operated, in which case the signals from them are of small power.

The *Nautophone* (4) is an electrically-operated instrument also fitted with a horn, and emits a high note signal similar in power and tone to that of the Reed

Gun (5) and *Explosive* (6) signals are produced by the firing of explosive charges, the former being discharged from a gun, and the latter being exploded in mid air.

Bells (7) may be operated either mechanically or by wave action, in which latter case the sound is irregular. The notes may be high, medium or low according to the weight of the bell. *Gongs* are also sometimes employed.

A *Whistle* (8) is a signal of low power and tone sometimes fitted on a floating body, when this is the case the sound is produced by air drawn in and compressed during the upward and downward movement of the body due to wave action, and is consequently irregular.

II. Submarine Sound Signals.

The *Oscillator* (9) is an electrically-operated instrument sounding a high note signal.

Bells (10) may be operated either mechanically or by wave motion, in which latter case the sound is irregular.

The effective range of submarine sound signals far exceeds that of air sound signals having been known to exceed 50 miles in the case of an oscillator and 15 miles in that of a bell. Their bearings can be determined with sufficient accuracy for safe navigation in a fog if a vessel is equipped with receivers, and even should a vessel be not so equipped submarine signals may be heard from below the waterline for distances which are well outside the range of air fog signals, though their bearings cannot then be so well determined.

III. Wireless Fog Signals.

These are provided for the purpose of position finding.

There are three types employed (11) *Beacon*, (12) *Revolving Beam*, and (13) *Rotating Beacon* or *Loop* Stations.

The *Beacon* Station (11) consists of an all-round wireless transmitter sending out a code signal in every direction, the bearing of which is obtained by means of a wireless direction finder or wireless compass fitted on board ship. When the wireless signal is combined

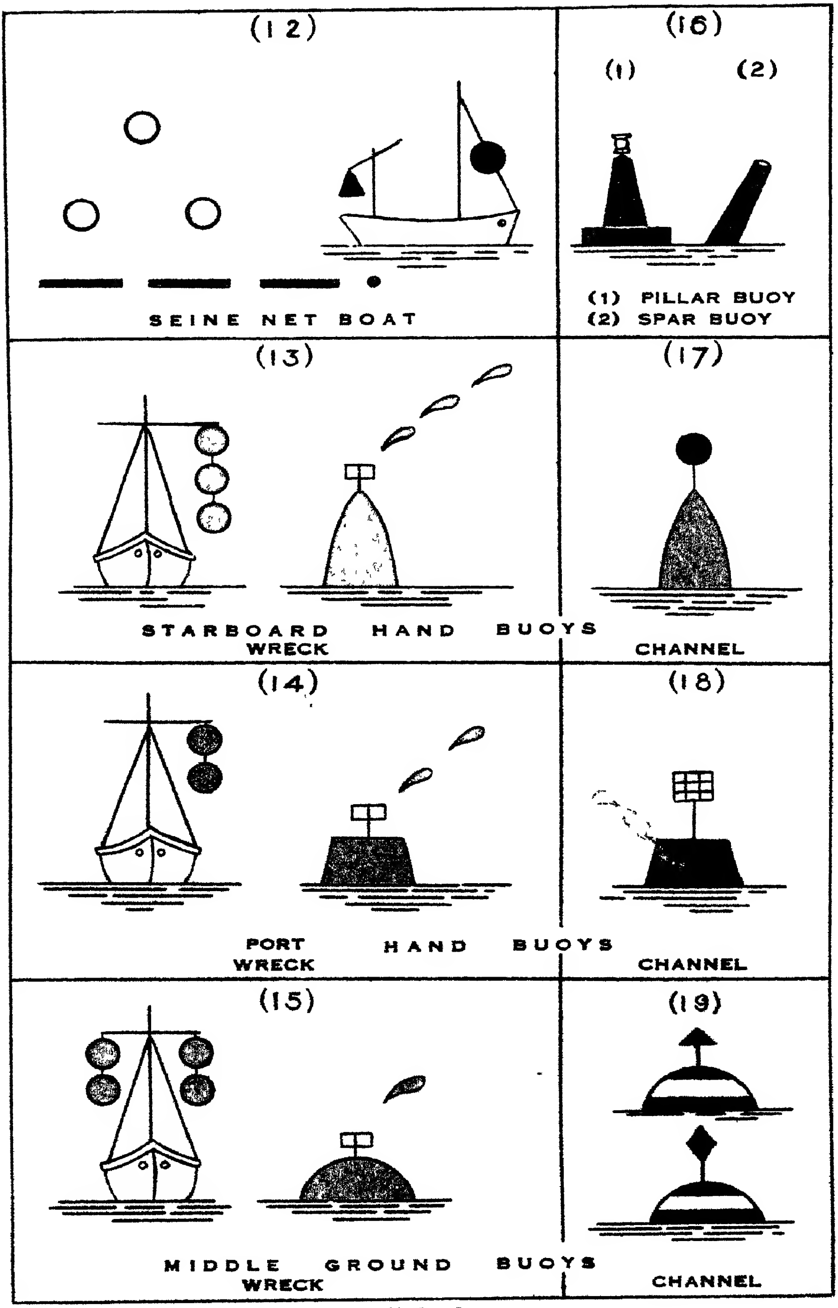
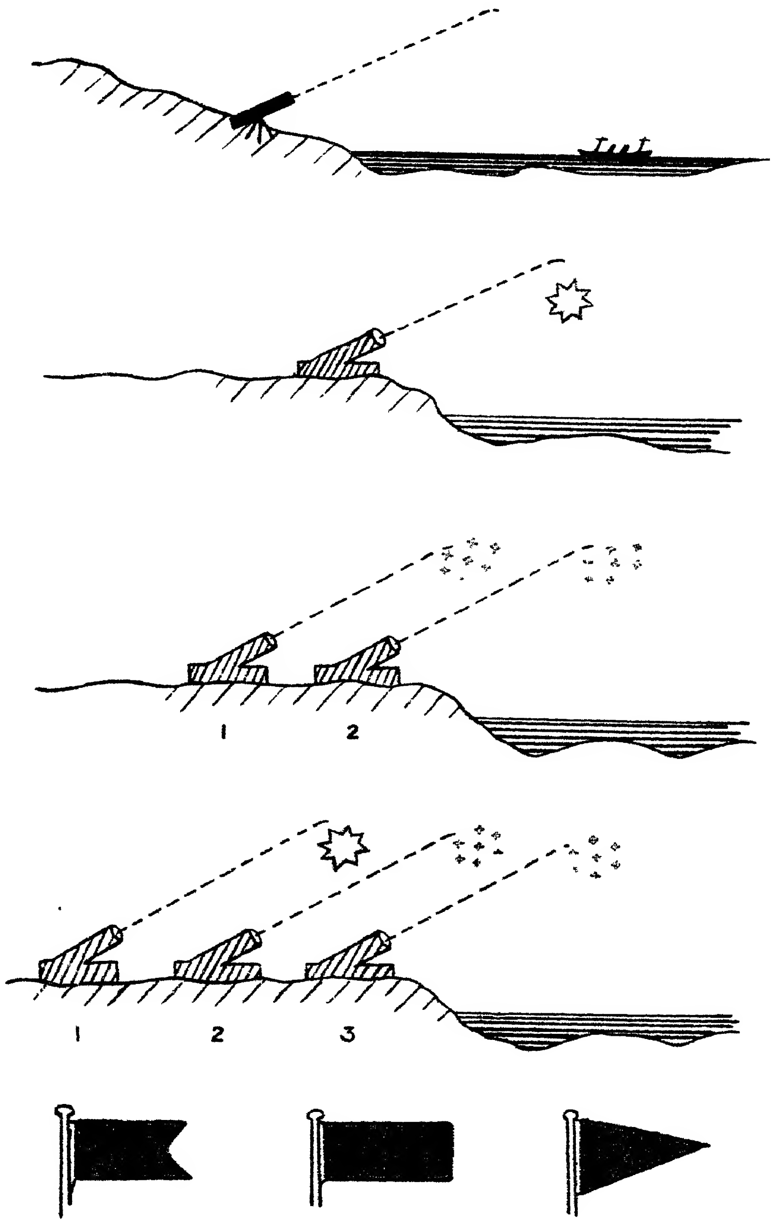

(12)
SEINE NET BOAT
(16)
(1)
(2)
(1) PILLAR BUOY
(2) SPAR BUOY
(13)
(17)
STARBOARD HAND BUOYS
WRECK
CHANNEL
(14)
(18)
PORT HAND BUOYS
WRECK
CHANNEL
(15)
(19)
MIDDLE GROUND BUOYS
WRECK
CHANNEL

FIG. 4



SIGNALS OF LIFE-SAVING SERVICE

FIG. 5

and synchronised with a submarine sound signal, distance, as well as bearing can be determined.

The *Revolving Beam* Station (12) consists of the emission on short wave-lengths of wireless signals projected in a narrow beam, a different Morse letter signal being transmitted for each point and half-point of the compass The navigator listens by means of a special type of wireless receiver (independent of the ordinary W/T installation) and hears a series of five or more Morse letters, transmitted at a uniform speed, as the revolving beam intersects the ship's course. The middle letter of the series indicates the exact bearing of the ship (derived from a special chart giving the lettered sectors) in relation to her course. By repeating the observations at short intervals and co-ordinating the results with the ship's course and speed, the exact position of the ship can be determined.

The *Rotating Beacon* or *Loop* Station (13) consists of a medium wave wireless beam transmitter rotating at a uniform speed. A continuous signal is transmitted with special code signals as the beam passes certain points of the compass These signals are received on a standard wireless receiver, and as the beam rotates the signal strength rises and falls being at a minimum as the beam passes the ship. As the speed of the rotation of the beam is known, the bearing of the station can be calculated by measuring the time interval between the beam passing a known point of the compass (indicated by the transmission of the code signal referred to above) and passing the ship (indicated by the minimum strength of signal)

II. VISUAL AND SOUND SIGNALS.

Signals used in connection with the Life-Saving Services on the Coasts of Great Britain and Northern Ireland.

Signal.	*Signification.*
(*a*) *Signals to Vessels in Distress*	
Rocket throwing *white* stars, or *white* flare.	Distress signal or plight observed — Assistance summoned.
One explosive sound signal showing bright *white* star on bursting.	Distress signal or plight observed — Life-Saving Apparatus called out.
Two explosive sound signals, showing bright *green* stars on bursting.	Distress signal or plight observed — Lifeboat called out.

Signal	*Signification.*
Three explosive sound signals, the first showing *white* star on bursting and the second and third *green* stars.	Distress signal or plight observed — Life-Saving Apparatus and Lifeboat called out.

Note 1.—By day a *Red* Flag (Rectangular or Swallow-tailed) will be flown when the Life-Saving Apparatus is called out, and a *Red* Flag (Triangular) when the Lifeboat is called out.

Note 2.—Certain pyrotechnic signals consisting of three or more rockets throwing *white* stars on bursting or a *green* flare turning to *white* are used on occasions for communication between the shore and a lifeboat. A lifeboat when out on service may make any of the following signals: A *white* flare to indicate that she is approaching a wreck. *Red* flares to indicate to the shore that more aid is required and a *green or green* turning to *white* flare to notify to those ashore that she is returning.

(*b*) *Landing Signals.*

Signal.	*Signification.*
By day.—Flag held upright over head. *By night.*—*White* flare held steady or stuck in ground.	You may attempt to land here.
By day.—Flag waved from side to side. *By night.*—*White* flare waved from side to side.	Landing is extremely dangerous. You are advised to lay off until lifeboat arrives.
By day.—Flag waved to right or left and then pointed in direction. *By night.*—*White* flare held steady and carried along shore to right or left.	The best landing will be found in the direction in which flag is pointed or light carried.
By day.—Two flags held upright overhead, the men holding them being about 50 yards apart in line of approach. *By night.*—Two *white* flares held or stuck in ground or two bonfires placed as above.	You should attempt to land and by this line of approach.

(*a*) *Standing into Danger Signals.*

Signal.	*Signification.*
The International Code Signal JD The letter U (▪ ▪ ▬) flashed by lamp or made by foghorn, or whistle, etc.	You are standing into danger.

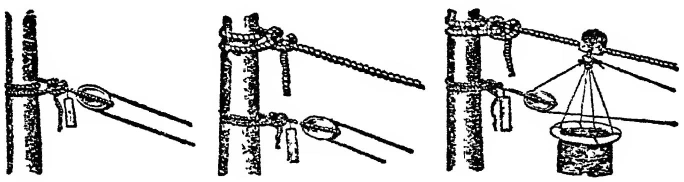
Note.—If it should prove necessary, the attention of the vessel is called to these signals by a *white* flare, a rocket showing *white* stars on bursting, or an explosive sound signal.—*June* 1, 1930.

The actual launching of the lifeboat is notified by a green Verey's light.

BOARD OF TRADE INSTRUCTIONS.

For the Guidance of Masters and Seamen when using the Rocket Apparatus for Saving Life

In the event of your vessel stranding on the coasts of the United Kingdom, and the lives of the crew being placed in danger, assistance will, if possible, be rendered from the shore in the following manner, namely:—



(i) (ii) (iii)

Fig 1.

1. A rocket with a thin line attached will be fired across your vessel. Get hold of this line as soon as you can, and when you have *secured it*, let one of the crew be separated from the rest, and, if in the day time, wave his hat, or his hand, or a flag or handkerchief: or, if at night, let a rocket, a blue light, or a gun be fired, or, let a light be waved as a signal to those on shore.
2. When you see one of the men on shore separated from the rest wave a *red* flag, or, if at night, wave a *red* light; you are to haul upon the rocket line until you get a tailed block with an endless fall rove through it (Figure (i)).
3. Make the tail of the block fast to a *mast well above the deck*, or if your masts are gone, then to the best place that can be found—

bearing in mind that the lines should be kept clear from chafing the wreck, and that space is left above for the hawser (see par. 5). When the tail block is made fast, and the rocket line unbent from the whip, let one of the crew, separated from the rest, make the signal required by Article 1 above

4. As soon as the signal is seen on shore, a hawser will be bent to the whip line, and will be hauled off to the ship by those on shore.
5. When the hawser is got on board, the crew should at once make it fast to the same part of the ship as the tailed block is made fast to, *only about 2 feet higher* (Fig (ii)) *taking care that there are no turns of the whip line round the hawser*, the whip should then be unbent from the hawser.
6. When the hawser has been made fast on board, the signal directed to be made in Article 1 above is to be repeated.
7. The men on shore will then set the hawser taut, and by means of the whip line will haul off to the ship a sling lifebuoy, into which the person to be hauled ashore is to get (Fig. (iii)). When he is in and secure, one of the crew must be separated from the rest, and again signal to the shore as directed in Article 1 above. The people on shore will then haul the person in the sling to the shore, and when he has landed will haul back the empty sling to the ship for others This operation will be repeated until all persons are landed.
8. It may sometimes happen that the state of the weather and the condition of the ship will not admit of a hawser being set up; in such cases, a sling lifebuoy will be hauled off by the whip, which will be used without the hawser.
9. This method is only adopted when shipwrecked persons have to be landed on to a pier or high ground, and is never to be used on flat shores.

Masters and crews of stranded vessels should bear in mind that **success** in landing them in a great measure **depends upon their** coolness, **and attention to the rules here laid down**; and that by attending to them many lives are annually saved by the rocket apparatus on the coasts of the United Kingdom.

The System of Signalling must be strictly adhered to; and all women, children, passengers, and helpless persons should be landed before the crew of the ship.

DISTRESS SIGNALS.

Two of the statutory signals, viz., "a continuous sounding with any fog signal apparatus," and "flames from the ship," are liable to be confused with a vessel making similar signals merely to attract attention only, or, providing working flares on fishing boats.

It is recommended that Morse signals of distress made on a fog horn or with a lamp should be a continuous repetition of S O S (Morse) and the same for a visual distress signal on a lamp.

Instead of flames from the vessel it is recommended that red flares should be used and, particularly, a firework signal showing a brilliant red flare and throwing five or more red stars to a height of 80 feet.

LIFE-SAVING APPLIANCES RULES—LINE-THROWING APPLIANCES ON SHIPS.

Every ship of 500 tons gross and upwards, when proceeding on a voyage or excursion from a port in the United Kingdom, must carry line-throwing appliances which shall be at least as effective as the following apparatus, viz.:—

Four 2-lb. line throwing rockets with suitable sticks capable of throwing a line 5/16ths inch in circumference a distance of 120 yards in calm weather. Two such lines, each not less than 240 yards in length, having a breaking strain of not less than 150 lbs.

Rockets—Should be specially made for line throwing (*i.e.*, without stars or detonating composition) by approved manufacturers. They should have a watertight outer case and should be marked with the date of manufacture. The means of ignition should be either by (i) slow-burning fuse at the base ignited by portfire or by (ii) a frictional striker applied to slow burning composition at the base or side of rocket. In either case the arrangement should allow for a delay of not less than three seconds before the rocket commences its flight. In the case of a frictional ignition, its striker should be carried, ready for use, in a small sheath on the rocket. Rockets should be replaced at least every five years.

Sticks.—To be not less than 5 feet in length and to be attached to the rocket when required for use by a spring clip engaging in a slot.

Container.—Rockets, lines and portfires (if used), with a copy of directions for use of the appliance, should be stowed together in a watertight case, *i.e.*, in a case which is sufficiently weathertight and watertight to keep the rockets available for use at any time.

The illustration shows the Schermuly Pistol Rocket Apparatus. The line is in the box, flaked in a special manner to ensure free running The line is attached to the rocket, the rocket fits on to the barrel of the pistol and is ejected from the muzzle by means of a cartridge, and immediately thereafter the rocket begins to function as a rocket proper carrying the line with it.

Fig 2.—The Schermuly Pistol Rocket Apparatus

Attention has been called by the Board of Trade to the danger of attempting to establish communication, by means of a rocket line-throwing apparatus, with an oil tanker, should that vessel be carrying petrol spirit, or other highly inflammable liquid and be leaking; petrol spirit rises to the surface of water. In such cases the assisting vessel should lie to **windward** of the **tanker** and the communication should be established from the ship requiring assistance. Before firing a rocket to such a vessel it should be ascertained whether it is safe to do so.

BELLS, WHISTLES AND FOG HORNS.

Bells.—All steam and sailing vessels must be provided with an efficient bell. The bell should be hung clear of all obstructions, and not less than 12 inches in diameter at the mouth, except in the case of small vessels under 150 feet in length working in rivers, estuaries or inland lakes, when a bell of not less than 8 inches in diameter may be accepted.

Steam Whistles.—All steam vessels and all vessels propelled by machinery on the high seas and in all waters connected therewith navigable by sea-going vessels are required to be provided with an efficient whistle or siren, sounded by steam or some substitute for steam, and so placed that the sound may not be intercepted by any obstruction. The whistle should be at least 8 feet above the deck forward of the foremost funnel and well clear of, and above, deckhouses, ventilators, etc.

Ordinary "organ whistles" should be not less than 30 inches high and 5 inches in diameter, and "harmony whistles," "bell chime" steam whistles and whistles or sirens of other approved types should be of proportionate dimensions

A whistle or siren is not to be regarded as efficient unless it is audible for at least 2 miles in a still condition of the atmosphere.

Whistle pipes should be so arranged that a full supply of dry steam will at all times be immediately available when the vessel is under way, and to ensure this it should not be possible for water to lodge in the pipes.

The pipes should not, as a rule, except in small vessels under 150 feet in length, be less than 2 inches outside diameter. All pipes should be lagged.

The whistles of all new vessels should be tried, and unless a full clear sounding blast is immediately produced they should not be passed.

Whistles on Motor Ships.—Vessels fitted with electric or oil motor engines, whether auxiliary or otherwise, for propelling purposes are steam vessels within the meaning of the Collision Regulations, and should therefore be provided with an efficient whistle or siren sounded by steam, or some substitute for steam. Compressed air may be used.

Small motor vessels, coasting or making short sea voyages, must carry an efficient mechanical or electric horn of a type capable of producing the sound signals required by the Collision Regulations, and, if fixed, must be so placed that the sound from it will not be unduly obstructed, and will carry a distance of at least 2 miles.

In the case of motor boats plying on rivers or inland lakes, a horn or an electric bell audible for at least half a mile may be allowed instead of a whistle, if the owners so desire.

Fog Horns.—Article 15 of the Collision Regulations requires that the necessary signals for vessels under way shall be given (1) by steam vessels on the whistle or siren; (2) by sailing vessels and vessels towed, on the fog horn. Whistles required for steam vessels are described above, but all steam vessels must, in addition, be provided with an efficient fog horn to be sounded by mechanical means.

Fog horns of the "rotary" and "crank bellows" type are the most efficient at present in use. "Plunger" type fog horns are rarely found to be efficient, and should only be accepted if *entirely* satisfactory.

Horns blown by mouth cannot be accepted as efficient on vessels plying on the high seas, or in waters connected therewith navigable by sea-going vessels.

SCREENING OF LIGHTS.

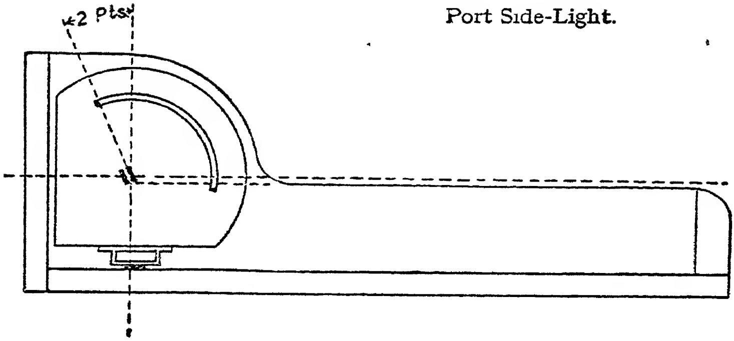
Side-Lights: Screening Abaft the Beam.—The wick or wicks of a side-light must be placed at an angle of 112½° with the fore-and-aft line of the ship; in other words they must be parallel to the direction two points abaft the beam. The burner must be so placed that a line drawn in this direction from the after edge of the wick in the case of a single burner, and of the forward wick in the case of a duplex burner, shall cut the edge of the housing of the lens.

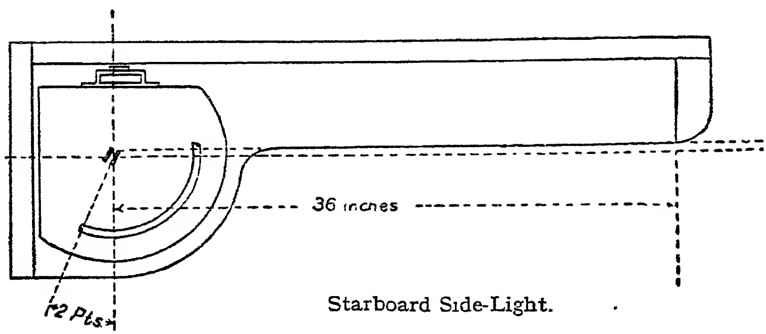
Side-Lights: Screening Forward.—The screens of side-lights, the length of which should never be less than 36 inches from the flame to the chock or its equivalent, must always be placed parallel to the line of the keel. The chocking must be so arranged to show a "thwartship value" of at least 1 inch of wick in a forward direction; that is to say, a person looking past the edge of the chock in a line parallel to the keel must be able to see at least 1 inch of wick.

Masthead Lights: Screening.—In a masthead light the wick or wicks must be at right angles to the line of the keel, and their setting must be such that lines drawn from the centre of the after edge of the wick in the case of a single burner, and of the forward wick in the case of a duplex burner, in directions two points abaft the beam on each side, shall cut the edges of the housing of the lens.

Stern Lights: Screening.—If a fixed stern light is fitted, the wick,

Port Side-Light.





Starboard Side-Light.

which must in this case be a single one, should be set as in the masthead light and so screened that a line drawn from the centre of the wick in a direction two points abaft the beam shall cut the edge of the housing of the glass front of the lantern.

Electric Lights.

18. General.—Electric lanterns are not required to be of a type approved by a certificate of approval and such certificates will not, in general, be issued. Subject to this, and except where otherwise stated or where the context implies otherwise, the instructions relating to lanterns in which oil is burned apply equally to those in which electric light is used. Separate lanterns must always be provided for electric and oil lamps, and oil lanterns must in every case be carried. Lanterns in which electric light is used should, as far as possible, be air-tight and the lanterns should be made to open from the top in order to afford facilities for cleaning and repair, and the checking of measurements.

An electric lantern should, as a rule, be fitted with a plain, colourless, glass front, cylindrical in form, which should be at least 5/16 of an inch in thickness, in order to obviate the probability of breakage. The glass should be highly polished and free from air bubbles or other visible defects. A dioptric lens may be fitted instead, if the owner so desires, but where this course is followed the lens must be of an approved type, and the lantern must comply strictly with para. 24.

19. **Voltage.**—The voltage of the electric supply on board should be not less than 110 or greater than 220 volts The supply of electric current for navigation lights should be kept at its full voltage throughout the voyage, and opportunity should be taken to point this out to masters of ships, as under-running of the voltage may result in serious loss of candle power.

20. **Candle Power.**—Either 60 watt or, preferably, 100 watt lamps, which will give candle powers of, approximately, 50 or 80 candles respectively, should be used.

21. **Form of Lamps.**—Metal filament lamps should be used in all cases, as carbon filament lamps of the candle power required involve risk of serious over-heating.

Lamps should be of the normal type, having the usual cylindrical ("squirrel cage") form of filament.

The diameter of the cage formed by the filament should be not less than 1 inch (*see* para 26) and not greater than 1⅜ inches.

22. **Double Filament Lamps.**—The use of double filament lamps, one filament of which is intended for working purposes and one for emergencies if the former fails, is not permitted, as it is impossible to obtain an adjustment of the screening which will be correct in relation to both filaments.

23. **Gas-filled Lamps.**—The Board of Trade are advised that these lamps, as at present manufactured, are not suitable for use in ships' navigation lanterns. Their use, accordingly, should not be permitted without prior reference to the Mercantile Marine Department.

24. **Position of Electric Bulb.**—The upright position (pip upwards) should be adopted in all cases.

If the lantern used with an electric lamp is fitted with a plain glass front, the exact height of the luminous centre of the source of light, in relation to the centre of the glass, is immaterial.

If, however, an electric lantern is fitted with a dioptric lens, the height of the socket is to be so adjusted that the luminous centre of the source of light coincides with the centre of the lens.

Further, in lights fitted with dioptric lenses, the luminous centre of the filament should always be the same distance above the cap, and to ensure that this condition is fulfilled a sufficient supply of spare lamps of identical dimensions should be carried on board. This reserve stock should be inspected.

25. **Side-Lights: Screening Abaft the Beam.**—Lamp sockets should be so placed in the lantern cases that a line drawn in a direction two points abaft the beam, touching the forward edge of a circle, $\frac{5}{8}$-inch diameter, concentric with the socket, will cut the edge of the housing. The centre of the lamp socket should be placed $\frac{5}{16}$ inch abaft the centre from which the curvature of the lens is struck.

26. **Side-Lights: Screening Forward.**—The chocking must be so arranged so as to show a "thwartship value" of at least 1 inch of filament in a forward direction.

27. **Masthead Lights Screening**—Lamp sockets should be so placed in the lanterns that lines drawn in directions two points abaft the beam on each side touching, tangentially, the forward side of a circle $\frac{5}{8}$-inch diameter concentric with the lamp socket will cut the edges of the housing of the lens. The centre of the lamp socket should be placed $\frac{5}{16}$ inch abaft the centre from which the curvature of the lens is struck.

28. **Fittings.**—The usual type of bayonet fitting should be used. The inside diameter of the socket should be $\frac{7}{8}$-inch, or $\frac{1}{4}$-inch larger than the diameter of the circle to which the light is screened abaft the beam, as described in paragraphs 25 and 27.

Special care should be taken to see that the lamps fit closely into the sockets, so that when in position they are upright and secure.

NOTICES TO MARINERS

Questions

1. Who issues Notices to Mariners and where are they obtained?

2. What signals are shown when a port is closed and what would you do on entering a closed port and no instructions were issued?

3. What lights are shown by an Examination vessel?

4. Give the day and night signals for a vessel sweeping for mines.

5. What precautions should be taken when approaching a squadron of warships?

6. What flag is displayed by a submarine escort and what action would you take on approaching her?

7. What lights are shown by an aircraft at anchor? What other vessel shows similar lights?

8. Give the signals of distress for aircraft.

9 Describe briefly how you would go about picking up a stray torpedo.

10. What precautions should be taken when shipping and discharging a pilot?

11. What precaution should be taken when a foreign pilot is piloting the ship?

12. What do you understand by the helm orders "starboard" and "port"?

13. When passing a lightship at night how could you tell how she was heading?

14. What signals are shown by a lightship driven from her station?

15 What is a "watch" buoy?

16. How could you distinguish any particular lightship by day if too far off to read her name?

17. What light is shown by a lightship when her distinguishing lights are out of action?

18. What signals are given by a lightship to warn off an approaching vessel?

19. A nearby warship hoists the Red Ensign, what does it mean?

20. What is the penalty for negligently fouling buoys and lightships?

21. You are crossing any vessel moored in a tideway, what precaution would you take?

22. A vessel with a bow rudder is coming out of a dock stern foremast, what day signal does she exhibit?

23. Describe how you would clear a telegraph cable brought to the surface with the anchor.

24. Give the day and night signals to be shown by a vessel as required by Port Health Authorities in U.K.

25. Give the day and night signals for a seine net fishing vessel.

26. What sound signals are given by a seine net fishing vessel when being approached by another vessel (i) in clear weather; (ii) in fog.

27. What precautions should be taken when approaching a fleet of net drifters showing flare-up lights?

28. Describe and illustrate the uniform system of buoyage with topmarks if any.

29. What degree of dependence can be placed on buoys, lightships and moored beacons?

30. What would you do when entering a port and sight the following signals?

(i) Three green lights vertical right ahead.
(ii) Two green lights vertical on starboard bow.
(iii) Four green lights (2 and 2 vertical) right ahead.
(iv) One green flash every 5 seconds on your port bow.
(v) A vessel painted green showing 3 green balls vertical from her yardarm.
(vi) Three strokes on a deep toned bell on starboard bow.
(vii) Two strokes on bell right ahead.
(viii) Four strokes on bell on port bow.

31 What measure of reliance can be placed on sound signals in fog?

32 What is (i) a "diaphone" signal, (ii) a "nautophone" signal; (iii) an "oscillator" signal?

33. Which are the more reliable, air sound signals or submarine sound signals?

34. State what you know of wireless fog signals in general.

35. Describe in general terms how W/T bearings are obtained on board ship from (i) a wireless beacon; (ii) a revolving wireless beacon; (iii) a rotating wireless beacon.

36. You have made signals of distress to the shore (Article 31), what do you understand the following reply signals to mean?

(i) A rocket throwing white stars.
(ii) An explosive sound signal showing a white star.
(iii) Two explosive sound signals in succession dropping green stars.
(iv) Three explosive sound signals in succession, 1st a white star, 2nd and 3rd green stars.
(v) A swallow-tailed red flag shown from the shore.
(vi) A triangular red flag shown from the shore.

37. You are compelled to make a landing with the ship's boat on a beach, what do you understand the following signals to mean when shown by the coastguards?

(i) A white flare when held steady.
(ii) A flag waved from side to side.
(iii) Two white flares held steady.

38. What signals are made from a lightship or by the coastguards on shore when a vessel is standing into danger?

39. Describe in detail step by step the procedure of getting communication by means of the rocket apparatus.

40. On what does the success of its operation depend?

41. What conditions must an approved line-throwing gun fulfil? What precautions should be taken when getting into rocket line-throwing communication with an oil tanker?

42. What is meant by an efficient bell?

43. What is an efficient steam whistle?

44. At what distance should the steam whistle be audible?

45. How are sound signals made in motorships?

46. How are side-lights screened, and what is the breadth of the wick in an oil side-light?

47. What candle power should electric navigation lights be?

48. What type of electric lamps should be used and what is the minimum size of filament?

CHAPTER XII.

PARALLELOGRAM OF FORCES

THIS is a graphical method of representing the resultant of two forces acting on a point and the method is applied to such questions in navigation and seamanship as may lend themselves to demonstration in this branch of mechanics

The proposition is stated as follows.—If two forces acting at a point be represented in magnitude and direction by the two adjacent sides of a parallelogram drawn from the point and the parallelogram be completed, then the diagonal drawn from the point of application represents the resultant force in magnitude and direction.

A Canal Boat.—A canal boat is towed from the bank by a rope *AR*. This pull is resolved into a fore-and-aft component *AP* propelling the boat ahead, and an athwartship pull *AQ* which draws her into the bank, but this is counteracted by the man who is steering when he pushes the helm, or tiller, two names for the same lever, a little to the starboard side of the boat, thus causing the blade of the rudder to incline to port and to keep the boat's head off the bank.

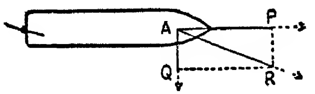


Fig. 1.

Current Sailing.—The triangle of forces also comes into current sailing, as demonstrated by the following example. A ship is steaming South at 12 knots with a current setting W.S W. at 4 knots. Find the course made good by the ship and her effective speed.

Construction.—With a protractor and a scale of equal parts, draw *AB*, South 12 miles, and *BC*, W.S.W. 4 miles. Join *AC*. Then *AC* is the direction the ship would travel over the ground and the length of *AC* is the distance she would cover in one hour.

The parallelogram may be completed by drawing *AD* parallel to *BC*, and *DC* parallel to *AB*.

The course made good is along *AC*, S. 16½° W., and her effective speed is the length of *AC*, 13⅓ miles

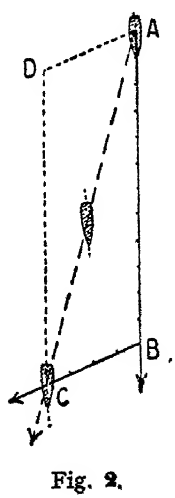


Fig. 2.

per hour, the effective speed being the velocities of the ship and current combined. Triangle ABC is a triangle of velocities.

Moorings.—The illustration shows a ship alongside a quay. The pull on the headrope AB is resolved into a fore-and-aft component AC and a transverse component AD, the force pulling ahead being considerably greater than the side pull, as indicated by the relative lengths of AC and AD.

The pull on the sternrope EF is resolved into two components EG and EH, the triangle of forces in this case being EGF. The transverse component is greater than the fore-and-aft component so that the rope EF will be a good **breast** but not much of a **spring**, whilst AB is a better **spring** than a **breastrope**.

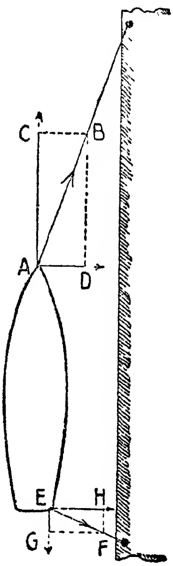


Fig 3

Action of the Rudder.—Figures 4 and 5 show respectively the turning and the retarding effect of a rudder angled at 20 degrees and angled at 40 degrees. If XY represents the plane surface of the rudder and PA the fore-and-aft stream current acting on it at A, then the water will be deflected in the direction AQ, because the angle of impact XAP and the angle of deflection QAY are equal, and RA is the resultant force acting at right angles to XY and bisecting angle PAQ.

Produce RA to B so that the length of AB is made equal, in convenient units, to the force acting on the rudder. This force will depend upon the area of the rudder and the velocity of the water impinging upon it. From A draw AD athwartship and AC fore and aft. Complete the parallelogram $ACBD$ The length of AD measured from the same scale represents the **turning** force acting on the rudder, and AC the **retarding** force which tends to reduce the speed of the ship.

It will be noted for the smaller angle of rudder, Figure 4, that its turning component is considerably greater than its retarding component, but that for the larger angle they are almost equal, that is $AD=AC$ nearly (Fig. 5). The maximum angle of turning efficiency of a ship's rudder is between 35 and 40 degrees; if the rudder is set at a larger angle than this the turning power is reduced and the retarding effect on the ship's speed is increased.

The lines on which a ship is designed is an important factor in

determining her speed of turning. Think of a round flat tub floating in water and of a deal plank kept floating on its edge by means of a keel. It is obviously much easier to turn the tub about a vertical axis than the

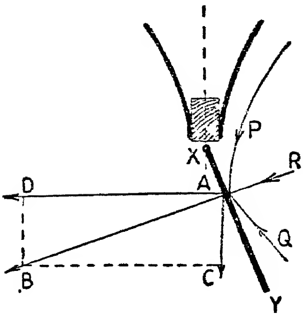


Fig. 4.—Rudder Angle 20°

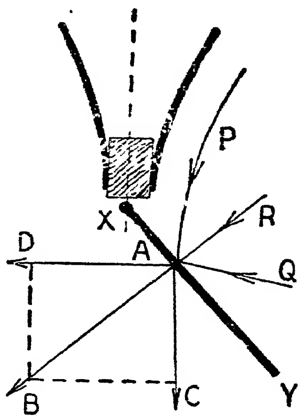


Fig 5.—Rudder Angle 40°

plank. Ships are designed on lines between these extremes, and a short, flat-bottomed, beamy ship turns quicker on her rudder than a long, deep narrow ship.

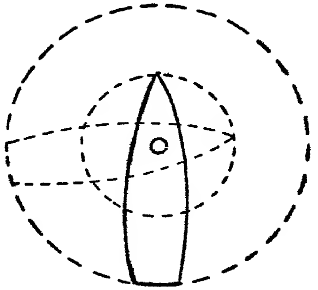


Fig. 6.

The Turning Centre of a ship when under way is situated about one-third her length abaft the stem, and it is necessary to keep this in mind when manoeuvring in narrow waters as the stern of the ship sweeps round the circumference of a larger circle than the stem. Figure 6 indicates the relative diameters of the circles, assuming for the

moment the ship to be almost stopped and rotated about her turning centre O

The stem sweeps round the circumference of the smaller circle and the stern post round that of the larger one

The Turning Circle.—It may be remarked here that when the rudder is put hard over in a sudden emergency, say a man overboard at A, the ship's turning pivot moves round on a circle and the vessel's keel makes an angle with the periphery of her turning circle, as indicated in Figure 7, her stern being thrown slightly outwards by the action of the rudder. When at position B the helm should be eased and the vessel steered

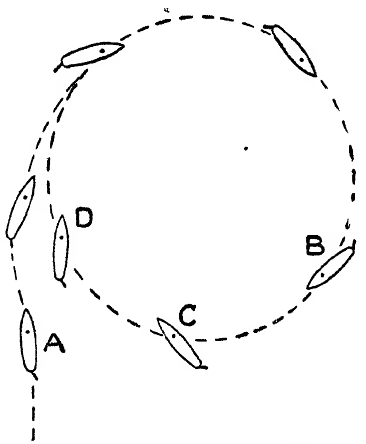


Fig 7.—The Turning Circle.

for A, because, if the rudder be kept hard over, she will continue turning through positions C and D. The turning circle will be uniform on the second round. The diameter of the circle depends on several factors, the length, breadth and draught of the ship, area of rudder, etc., but it is usually about six or seven times the length of the vessel; the time taken to complete the circle is also different for different ships but averages about 8 minutes.

True and Apparent Wind.—When a ship is stopped the direction indicated by a wind vane or by smoke from the funnel is the **true wind**. During a dead calm no wind would be felt on board a stationary ship, but when she gets under way a wind, or draught of air, will be felt as if it were coming from dead ahead. This is an **apparent wind** caused by the ship's progressive motion and this wind velocity will be equal to the speed of the ship.

When a ship steams at the rate of 10 knots directly into the teeth of a 40 miles per hour gale (force 8 on the Beaufort Scale), the velocity of the wind as registered by an **anemometer** on deck would be 50 m.p.h., and, conversely, if she were going in the opposite direction at 10 knots she would be running before the wind and the anemometer would register 30 m.p.h., that is 40 m.p.h. less 10 knots. The anemometer registers the **apparent wind**, which is the resultant effect of the true wind and the current of air due to the ship's motion.

Suppose a ship to be stopped, heading North, and the wind to be blowing from East at the rate of 20 m.p.h., then the wind would be on the starboard beam and the steamer's smoke would trail to the port beam at 20 m.p.h. If the ship now gets under way and steams North at 10 knots, the wind would appear to come from the starboard bow and the smoke would trend towards the port quarter. But how far abaft the beam? The parallelogram of forces will help us as illustrated in Figure 8.

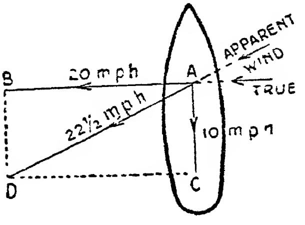


Fig. 8.—True Wind East; Apparent Wind N. 63° E.

From the ship A draw AB, West, and mark off 20 parts from any convenient scale of equal parts, then draw AC, South, and make it equal to 10 of the same parts. Complete the parallelogram by drawing CD parallel to AB and DB parallel to AC. The diagonal AD is the resultant of the two velocities (wind and ship) and gives the direction the steamer's smoke would go.

AD is the direction of the **apparent wind** as felt on board the ship, and its length, measured from the scale of equal parts, will be its velocity. The apparent wind comes from N. 63° E., velocity 22½ m.p.h., and the smoke will, of course, go S. 63° W.

Another Example.—Given a true wind from N.E., at 10 m.p.h., ship steaming East, 12 m.p.h. Find the direction and velocity of the apparent wind. Draw AB to the S.W. and equal to 10 units. Draw AC to the East and equal to 12 units. Join CB. Then CB is the apparent wind.

Ans.—N. 69° E., 20 m.p.h.

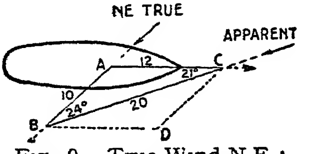


Fig. 9.—True Wind N.E.; Apparent Wind N. 69° E.

It will be noted that half the parallelogram is really all that is needed and ABC is called the **triangle of forces**.

On board ship, however, it is the apparent wind we experience and it is the **true wind** that should be recorded in the log book. A fairly good approximation of the direction of the true wind may be obtained from the sea as the wind blows at right angles to the normal wave crest, but our parallelogram may be helpful also.

Example.—The apparent wind is from East with a velocity estimated at 20 m.p.h.; the ship steaming North at 10 m.p.h. Find the direction and velocity of the **true wind.**

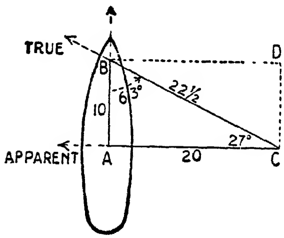


Fig 10.—Apparent Wind East, True Wind S. 63° E.

Make AB 10 miles due North, and AC 20 miles due East. Join CB and complete the parallelogram if desired. BC represents the direction and velocity of the true wind S. 63° E., 22½ m.p.h. This, of course, is the wind which would be experienced if the ship were stopped because it is the North-going speed of the ship which makes the apparent wind come from a direction more forward than the true wind.

Boat Sailing.—The principle of sail propulsion may be illustrated by a parallelogram of forces, as in the figure, where XY represents the plane surface of the sail and A the **centre of effort**, the name given to the point where the whole force of the wind is concentrated. The wind cannot go through the sail and the angle of its incidence with the sail at A, angle XAP is equal to its angle of deflection, angle YAQ: the impelling force RA acts along the line AB which is the bisector of angle PAQ and is always at right angles to the plane surface of the sail.

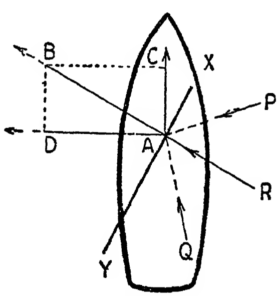


Fig 11.—Sail Propulsion

If this force were equal to a wind velocity of 10 m.p.h., then make AB equal to 10 parts from a convenient scale, and make BC perpendicular to the ship's fore-and-aft line drawn through A and we then have a triangle of forces. The parallelogram $ADBC$ may be completed if desired.

AB represents the direction the boat would go if she were a free agent; AD represents that part of the wind force which pushes the boat to leeward and AC the part that pushes her ahead. The resistance

of the water and the shape of the hull are two factors also operating on the boat, and the object of yacht designers is to build a boat that will respond fully to the forward component *AC* and resist the side component *AD*.

Cargo Spans.—The tension on the pendants of a span between two masts can be readily arrived at by constructing an appropriate parallelogram of forces The illustration shows the usual school apparatus for demonstrating the principle. The arrangement of pulleys and weights

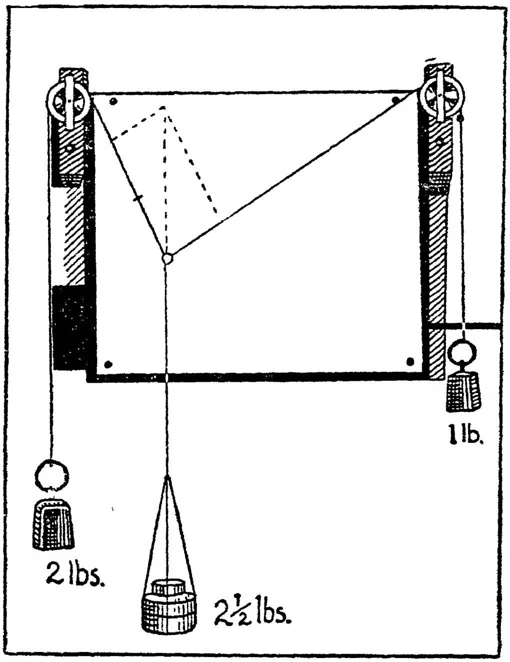


Fig 12 —Balanced Forces.

is obvious. A bight of cord has been led over two pulleys and a weight slung in the centre of it. The weight happens to be 2½ lbs., and it is balanced in equilibrium by a 2-lb. weight at the end of the cord leading over the left hand pulley and a 1-lb. weight at the end of the cord over the right hand pulley, thus indicating that the tension on the left hand cord is 2 lbs. and on the right hand cord 1 lb., the respective pendants making angles of 22 degrees and 53 degrees with the vertical.

By increasing or decreasing the weights relatively to each other the

apparatus will illustrate very clearly the corresponding changes in the angles formed by the pendants and the tensions on the spans. It will be recognised that the greater tension will be on the span which is nearer to the vertical and that the tension on each will be at its maximum when the span is taut, as seamen say when the pendants form nearly a straight line between the pulleys.

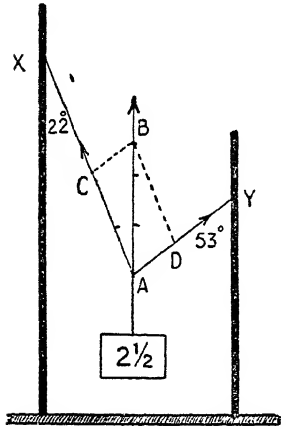


Fig. 13

The same results may be arrived at by construction as follows:—

Example.—Two pendants form a span slung between two masts making angles with the vertical of 22 and 53 degrees. Find the tension on each arm, or pendant, of the span when supporting a weight of 2½ tons.

Construction.—Draw two parallel vertical lines to represent the masts; make angles *X* and *Y* equal to 22 and 53 degrees respectively. Points *X* and *Y* are placed anywhere on the masts and represent the positions where the ends of the pendants are made fast. The lines of the angles intersect at *A*. Now draw *AB* vertically upwards and equal in length to 2½-ton units from a scale of equal parts. Draw *BC* parallel to one span and *BD* parallel to the other. The length of *AD* represents the tension (1 ton) on the arm from *Y*, and *AC* the tension (2 tons) on the arm from *X*.

Another Method is to give the lengths of the pendants and the heights of their standing ends above the deck as measured from the rigging plan of the ship, then draw out the facts to scale and construct the parallelogram.

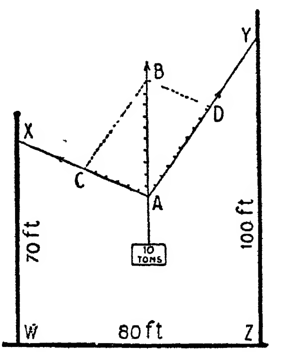


Fig. 14.

Example.—The horizontal distance between two vertical masts is 80 feet. The end of one pendant, 60 feet long, is made fast 100 feet up one mast and the end of another pendant, 50 feet long, is made fast 70 feet up the other mast. It is intended to lift a 10-ton boiler by using the pendants as span. Find the tension on each.

Construction.—Make ZW equal to 80 feet, from a convenient scale, and erect perpendiculars $WX=70$ feet and $ZY=100$ feet. With centre X and radius 50 feet on a pair of compasses describe an arc, and with centre Y and radius 60 feet describe another arc cutting the first one at A. Join AX and AY. The 10-ton weight will be suspended from A. AB is now drawn vertically upwards and made equal to 10 equal parts to represent unit-tons and not necessarily from the same scale as before as the parallelogram would probably be too big. BC is then drawn parallel to YA and BD parallel to XA. The length of AD measured in the same units as AB gives the tension on the pendant AY ($9\frac{1}{4}$ tons), and the length of AC the tension on XA (6 tons).

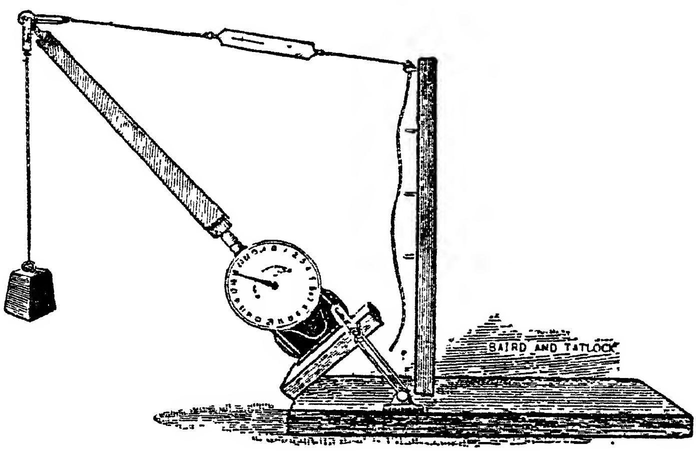


Fig. 15.—Derrick Apparatus.

Derricks.—A piece of school apparatus to demonstrate the thrust on the heel of a derrick and the tension on the span is shown in Figure 15. A given weight is seen hanging from the end of the derrick, its heel being fitted into a circular weighing balance which registers the thrust at the heel, the tension on the span being registered on a flat balance.

The thrust on the heel of a derrick and the tension on the span leading to the mast due to a weight hanging from the derrick end may be determined by means of a parallelogram.

Example.—A derrick 48 feet long is kept upended by means of a span 24 feet long attached to a point on the mast 40 feet vertically above the heel of the derrick. Find the tension on the span and the

thrust on the gooseneck of the derrick when a weight of 4 tons is hanging from its top end.

Construction.—Draw the figure to scale by making XY=40 feet, then with centre Y and radius 24 feet describe an arc, and with centre X and radius 48 feet describe another arc cutting the first one at A. Join AX and AY. Draw AB vertically downwards from A and make AB equal to 4 units from any convenient scale to represent the downward force of the suspended weight. Draw BC parallel to the span and CD parallel to AB; $ABCD$ is the parallelogram of forces.

The tension on the span is given by the length of AD ($2\frac{1}{2}$ tons), and the thrust on the gooseneck by AC ($4\frac{3}{4}$ tons).

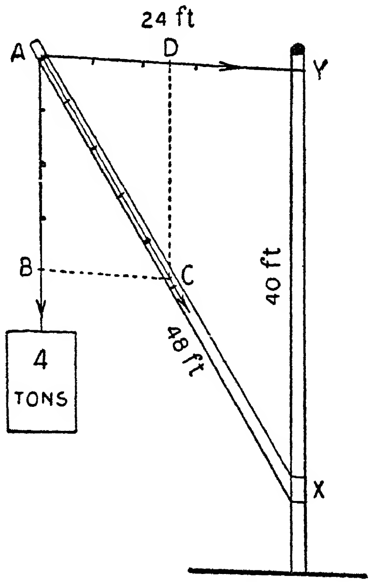


Fig 16.—A Hanging Weight.

A weight simply hanging from the end of a derrick is not the usual condition on board ship. The load is lifted by means of a wire fall which leads through a cargo gin at the top end of the derrick and down through a leading block at the heel of the derrick and thence to the barrel of a winch on deck, the thrust on the gooseneck of the derrick being thereby more than doubled, as, obviously, when a wire fall is used the pull exerted by the winch to hold the weight must be equal to the weight itself and the cargo gin has to bear the double weight.

Example.—Assuming the same conditions as in the previous example, viz. derrick 48 feet long, span 24 feet long, led through a span block on the mast shackled to an eyebolt 40 feet above the heel of the derrick. A single fall is led down the derrick through a leading block to a winch as shown in Figure 17. Find the thrust on the heel of the derrick and the tension on the span.

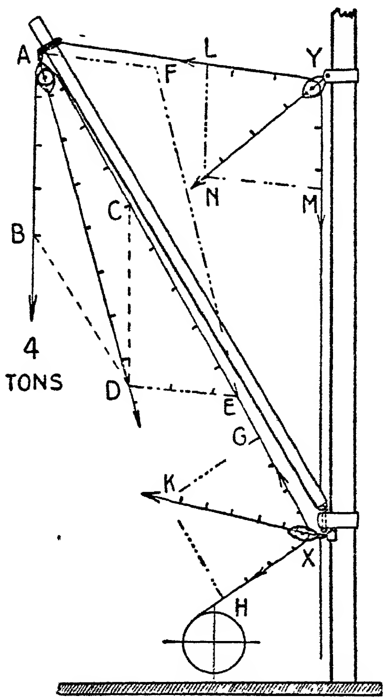


Fig. 17.—A Single Cargo Fall.

(i) In parallelogram $ABDC$, AB is the load (4 tons)$=AC$. AD is the resultant load on block A ($7\frac{1}{2}$ tons).

(ii) In parallelogram $ADEF$, AD is $7\frac{1}{2}$ tons, DE is the tension on the span ($2\frac{1}{2}$ tons), AE is the thrust on the derrick ($8\frac{3}{4}$ tons).

(iii) In parallelogram $XGKH$, $XG=XH$ the load (4 tons), XK is the stress on the heel block ($5\frac{1}{2}$ tons).

(iv) In parallelogram $YLNM$, $YL=YM$ the tension on the span ($2\frac{1}{2}$ tons), YN is the stress on the span block ($3\frac{1}{2}$ tons).

First, consider the stress at A in the figure due to the load and the tension on the fall to hold the load.

Construction.—Make AB and AC both equal to 4 unit-tons. Draw BD parallel to the derrick and DC parallel to the fall. Join AD. Then AD is the diagonal of the parallelogram $ABDC$ and represents the resultant of the two loads acting on the cargo gin, namely, the 4-ton weight and the 4-ton power exerted by the winch to balance the weight. The resultant AD is equal to $7\frac{1}{2}$ tons as measured from the scale.

Second.—Consider the stress at A due to the resultant AD and the tension on the span along AY to keep the derrick in position.

Construction—Draw DE parallel to the span and EF parallel to AD. Then AD and AF represent in magnitude and direction two forces acting at A, and the diagonal AE of the parallelogram $ADEF$ represents the thrust on the derrick ($8\frac{3}{4}$ tons) and AF or DE the tension on the span ($2\frac{1}{2}$ tons). Thus two parallelograms are required to solve the problem.

Third.—It may be required to find the stress on the leading block at X. We would then make XG and XH equal to 4 tons which is the weight being lifted, and complete the parallelogram $XGKH$. The diagonal XK represents the stress on the block X ($5\frac{1}{2}$ tons), and is the resultant of the two forces XG and XH acting at X. The angle GXH would need to be known to construct this parallelogram.

Fourth—The stress on the span block may be found in a similar way by making YM and YL each equal to DE, which represents the tension on the span ($2\frac{1}{2}$ tons). Complete the parallelogram $YMNL$. The diagonal YN represents the stress on the span block at Y ($3\frac{1}{2}$ tons). It is the resultant of the two forces YL and YM acting at Y.

No allowance has been made in the foregoing examples for the weight of tackle and the derrick, but it will be understood that upending the derrick increases the thrust at the heel and reduces the tension on the span, also that a derrick swings easier when the heel is stepped vertically below the point where the span is secured to the mast, that is where X is exactly below Y.

Another Example.—When the lifting fall is turned into a purchase the thrust on the derrick is reduced by an amount depending upon the power gained by the purchase, because the pull on the hauling part to hold the weight is thereby reduced.

Given the length of a derrick 25 feet; heel to span block on the mast 20 feet; length of span 18 feet; the angle the fall makes at the heel block leading to the winch is 92 degrees; weight to be lifted 10 tons; lifting

purchase two single blocks, the standing end of the fall being at the upper block.

Find (1) The stress on the shackle of the upper gin block; (2) the thrust on the derrick; (3) the tension on the span; (4) the stress on the leading block; (5) the stress on the span block.

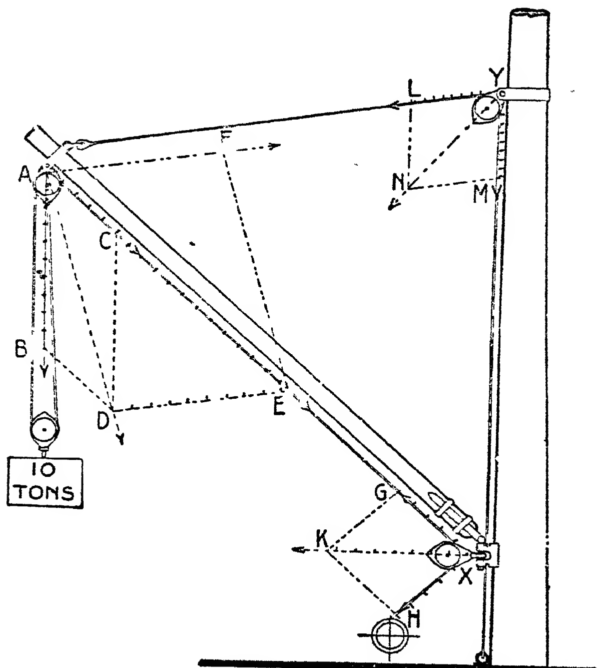


Fig 18 —A Single Purchase Fall

XY = 20 ft, XA = 25 ft, YA = 18 ft.
In parallelogram $ABDC$, AB = 10 tons, AC = 5 tons, AD = 14 tons
In parallelogram $ADEF$, AD = 14 tons, AF = 9½ tons, AE = 17½ tons
In parallelogram $XGKH$, XG = XH = 5 tons, XK = 7½ tons.
In parallelogram $YLNM$, YL = YM = 9½ tons, YN = 14½ tons.

Construction.—(1) Draw the mast, derrick, span, etc., to a convenient scale. The pull on the hauling part of the fall will be approximately half the weight as the power gained by the guntackle purchase is two. Make AB=10 tons; AC=5 tons; draw BD parallel to the derrick and CD parallel to the fall; join AD, which will be the diagonal of the parallelogram $ABDC$; AD represents the resultant of the two forces acting at A, viz., the load of 10 tons and the power of 5 tons required to hold it in suspension. AD is the stress on the shackle (14 tons).

(2) and (3) Draw DE and AF parallel to the span and EF parellel to AD to meet AF. The two forces acting at A, viz., the resultant AD and the tension on the span AF, are now represented graphically by the parallelogram $ADEF$, its diagonal AE being the magnitude of the thrust on the derrick ($17\frac{1}{2}$ tons) and the length of AF or DE gives the tension on the span ($9\frac{1}{4}$ tons).

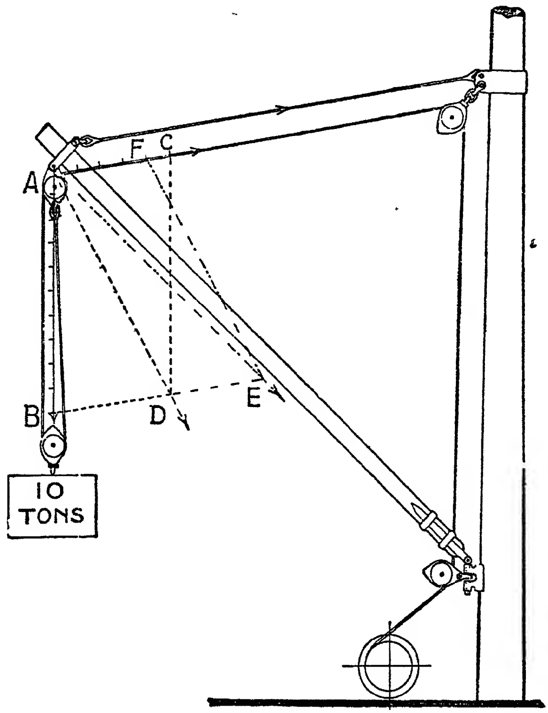


Fig 19—Hauling part led to Masthead.

AB = 10 tons
$AC = BD$ = tension on fall = 5 tons.
AD the resultant $10\frac{1}{2}$ tons
AE the thrust on derrick $12\frac{1}{2}$ tons.
AF tension on span 4 tons

(4) To find the stress on the leading block, make XG and XH each equal to the pull on the hauling part of the fall 5 tons, and complete the parallelogram $XGKH$. Join XK.

The length of the diagonal XK represents the stress on the leading block ($7\frac{1}{2}$ tons) which, is the resultant of the two forces acting at X, viz., the fall leading up the derrick and down to the winch.

(5) At the masthead make YL and YM each equal to the tension on the span ($9\frac{1}{4}$ tons) and complete the parallelogram $YLNM$ Join YN, then YN represents the stress on the span block ($14\frac{1}{2}$ tons)

The thrust on the derrick would be considerably reduced if the fall were led from the derrick head to a lead block at the masthead and then down to the winch as illustrated in Figure 19.

Assuming the same dimensions as before, viz, derrick 25 feet, height of span 20 feet up from the heel of derrick, length of span 18 feet. Find the thrust on the derrick and the tension on the span. (Fig. 19).

In the figure AB is equal to 10 unit-tons, AC to 5 unit-tons. Complete the parallelogram $ABDC$. The length of AD gives the resultant stress at A, $10\frac{1}{2}$ tons instead of 14 tons, as in previous example.

Draw DE parallel to the span to meet the line of the derrick AE at E Draw EF parallel to AD In the parallelogram $ADEF$, AE gives the thrust on the derrick ($12\frac{1}{2}$ tons) and AF the stress on the span (4 tons) These measurements may be checked from the scale on AB with a pair of compasses

By leading the fall from the derrick end through a block at the masthead instead of straight down the derrick as in Figure 18, the thrust on the heel of the derrick has been reduced from $17\frac{1}{2}$ to $12\frac{1}{2}$ tons in this example, and the stress on the span from $9\frac{1}{4}$ to 4 tons, thus demonstrating the advantage of distributing the stresses as widely as may be convenient and practical.

Cargo Slings.—*Example.*—A beam 10 feet long and weighing 20 cwts. is slung by means of a two-legged sling shackled to the ends of the beam The legs are 6 feet long, find the tension on each leg

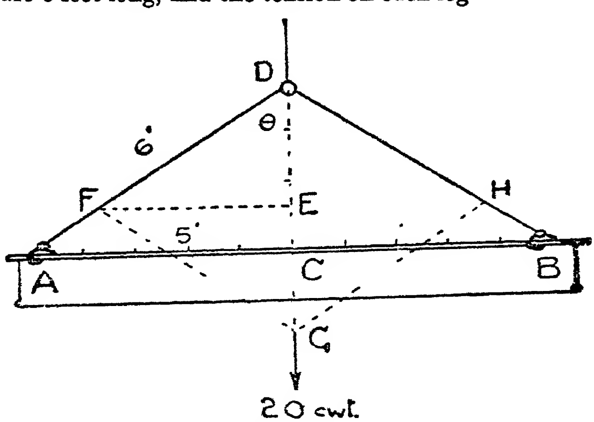


Fig. 20.

Construction.—In fig. 20 (1) make $AB=10$ feet to represent the distance between the shackles

(2) Bisect AB at C and erect the perpendicular $C\ D$.

(3) With centres A and B and radius 6 feet describe two arcs cutting each other at D. Join AD and BD.

(4) From any convenient scale, not necessarily the one used above, make $DG=20$ units$=20$ cwts.

(5) Draw GF and GH parallel to BD and AD respectively.

The lengths of DF and DH measured from the same scale give the tension on each leg, viz., 18·1 cwts.

Calculation—In triangle ACD given $AC=5$ feet, $AD=6$ feet, angle $C=90°$. Find angle ADC (θ).

$$\text{Nat. cosec } \theta=\frac{AD}{AC}=\frac{6}{5}=1{\cdot}2 \therefore \theta=56° \ 26'. \ *$$

Triangle GFD is isosceles, and if FE be drawn perpendicular to GD then it will bisect it at E and DE will represent half the load, that is 10 cwts.

In triangle DFE, given $DE=10$ cwts., $\angle\ \theta=56°\ 26'$, $\angle E=90°$. Find DF. $DF=DE$ Sec $\theta=10$ sec. $56°\ 26'=10\times1{\cdot}81=18{\cdot}1$ cwts.

The tension on each leg is therefore 18·1 cwts.

In this example we were given the length of the legs of the sling together with the load, and were asked to find the tension on the legs, but the question could be reversed by asking us to find the length of the legs when the tension on them is given, as in the following example.

Example.—It is required to lift a beam weighing 4 tons by means of a chain sling attached to a ring, the test working load of the chain being 3 tons. Find the minimum length of chain for each leg of the sling when the spread between the shackles is 16 feet.

Construction.—In fig. 21 (1) draw a vertical line DC and make DG equal to 4 units, from any convenient scale, to represent 4 tons, the weight of the beam.

(2) With centres D and G and radius 3 units$=3$ tons, describe arcs cutting each other at F and H. Join DF and DH and produce the lines to represent the legs of the sling.

(3) Through D draw XY at right angles to CD, and make DX and DY each equal to 8 feet from any convenient scale.

* The values of natural sines, tangents, secants, etc., are given in *Norie's Nautical Tables.*

(4) Through X and Y draw lines parallel to DC cutting DF and DH produced at A and B respectively. AB then represents 16 feet. the spread between the shackles.

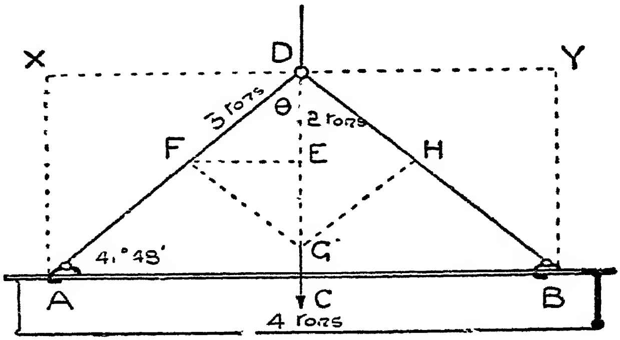


Fig 21.

(5) The length of DA, or of DB, measured from the same scale, gives the required lengths of the legs of the sling, viz., 10·7 feet.

Calculation.—First, find angle θ, which is the angle between the legs of the sling and the perpendicular dropped from their intersection at D. This might be done as a side issue, because in triangle DFE $DF=3$ tons, $DE=2$ tons, $\angle E=90°$. Find $\angle FDE$ or θ.

$$\text{Nat. sec. } \theta=\frac{DF}{DE}=\frac{3}{2}=1{\cdot}5 \therefore \theta=48° \; 12'.$$

Having found θ, make $\angle CAD$ equal to $(90°-48° \; 12')=41° \; 48'$. Then AD measured from the same scale as AB will give the minimum length of the leg. It is easy to calculate it because

$$AD=AC \text{ cosec } \theta=8 \text{ cosec } 48° \; 12'=8\times1{\cdot}34=10{\cdot}72 \text{ feet.}$$

By making the legs longer their angle of intersection would be smaller and the tension on each reduced. The same result could be got by closing in the shackles A and B on the beam thus making the base of the triangle ADB smaller.

Example.—A beam weighing 3 tons is being lifted by means of a sling, the legs of which are each 6 feet long. If the tension on each leg is 2 tons, find the distance between the shackles, assuming that the weight of the beam is evenly balanced on the sling.

Construction.—(1) Draw a vertical line DC and lay off $DG=3$ tons.

(2) Bisect DG at E, and draw EF perpendicular to DG.

(3) With centre D and radius 2 tons describe an arc cutting EF at F.

Join DF and produce DF to A so that $DA=6$ feet Draw CA perpendicular to DG and produce it to B, so that $CB=CA$ AB is the distance between the shackles, viz , 7·9 feet

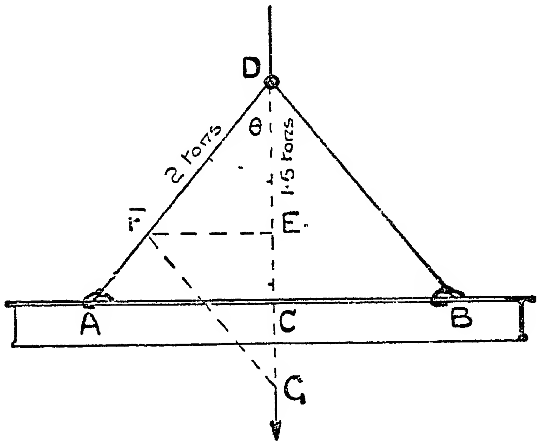


Fig 22.

Calculation.—

In triangle DEF. Given $DF=2$ tons, $DE=1{\cdot}5$ tons, $\angle E=90°$. Find $\angle FDE\,(\theta)$

$$\sec\theta=\frac{FD}{DE}=\frac{2}{1{\cdot}5}=1{\cdot}333 \quad \therefore\ \theta=41°\ 25'$$

In triangle DAC. $DA=6$ ft., $\angle\theta=41°\ 25'$. $\angle C=90°$. Find AC.
$AC=AD\sin\theta=6\sin 41°\ 25'=6\times{\cdot}662=3{\cdot}972$.
$AB=2\ AC=2\times3{\cdot}972=7{\cdot}944$ ft.
Distance between shackles A and $B=7{\cdot}944$ ft.

Example.—A square cargo tray $4'\times4'$, slung by four corner legs each leg 7 feet long and meeting in a ring at the top, supports a weight of 20 cwt. Find the tension on each leg of the sling.

Construction.—Make a preliminary sketch to illustrate the question as in fig. 25. Assuming the load to be evenly distributed on the tray so that its centre of gravity acts downwards at C, the middle of the tray, then each leg of the sling will do the same amount of work. Consider one pair of diagonal legs, DA and DB, to be doing all the work, and

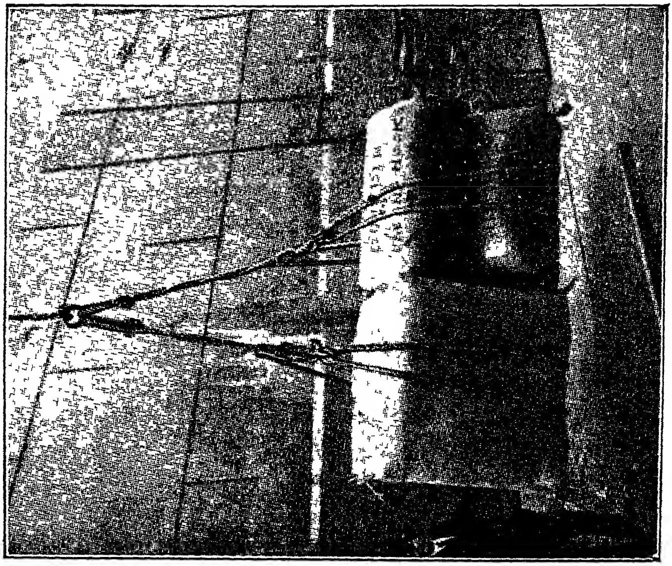


Fig. 24.

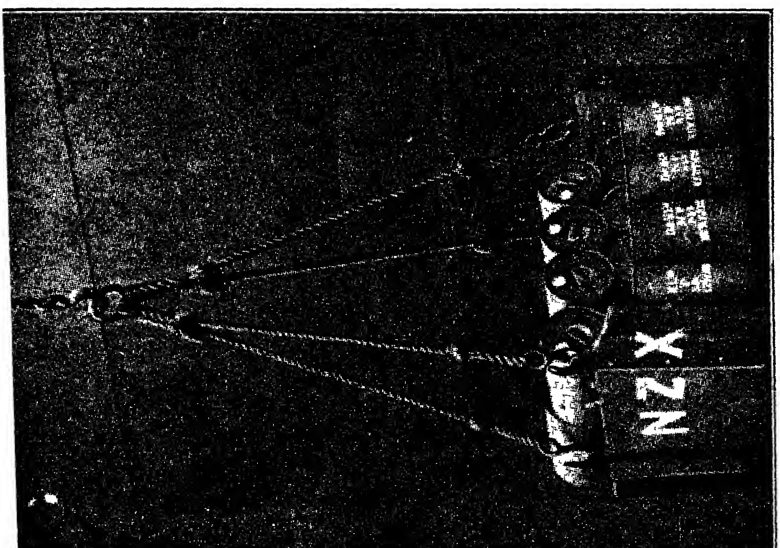


Fig. 23.

solve the triangle ADB, just as if AB were a beam as in the previous examples, but we must first find the length of AB.

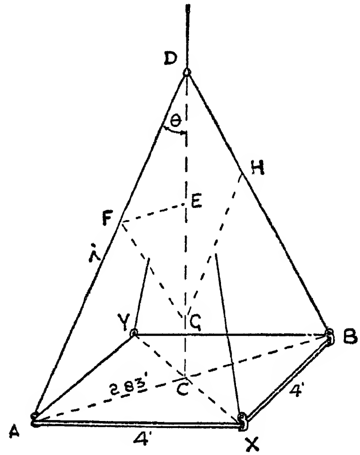


Fig. 25.

Draw fig. 26, $AYBX$ to represent the square tray and note that

$$AB^2 = AY^2 + YB^2 = 4^2 + 4^2 = 32$$

$$\therefore AB = \sqrt{32} = 5{\cdot}66 \text{ and } AC = 2{\cdot}83 \text{ feet.}$$

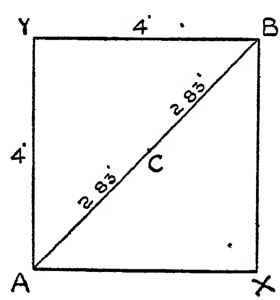


Fig. 26.

We can now construct triangle ACD to scale as in fig. 27 by making $CA = 2{\cdot}83$ feet, CD perpendicular to AC, and $AD = 7$ feet. Then construct the triangle of forces DGF, making $DG = 20$ cwt., and GF parallel to DH. The length of DF as measured from the scale of weights gives the tension on each of the two legs DA and DB, viz., 10·9 cwts., assuming that they alone were supporting the load; but the other two

legs are doing the same amount of work and relieve them of half their load so that each leg supports $\frac{10 \cdot 9}{2}=5 \cdot 45$ cwts.

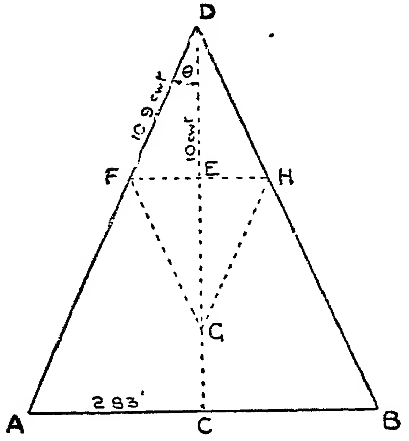


Fig. 27.

Calculation.—Having found the length of the half diagonal AC to be 2·83 feet, the triangle ACD may be solved as follows:—

$$\text{Cosec } \theta=\frac{AD}{AC}=\frac{7}{2 \cdot 83}=2 \cdot 473 \therefore \theta=23^\circ\ 51'.$$

In triangle DFE, given $\angle\ \theta=23^\circ\ 51'$. $DE=10$ cwts., $\angle E=90^\circ$. Find DF the tension on the sling.

$DF=DE$ sec. $\theta=10$. sec. $23^\circ\ 51'=10\times 1 \cdot 09=10 \cdot 9$ cwts being the tension on two legs, or 5·45 cwts on each of the four legs.

Ships' Cargo Lifting Blocks.—The following extracts are taken, by permission of the British Engineering Standards Association, from British Standard Specification No. 408, Ships' Cargo Lifting Blocks, official copies of which can be obtained from the Director of the Association, 28 Victoria Street, London, S W.1, price 2s. 2d. post free. The specification is issued for the guidance of manufacturers who make steel or iron cargo blocks and wish to subject them to tests preliminary to their being guaranteed as British Standard Blocks. The principal conditions of the tests are as follows:–

Definition.—"Block" shall apply to all ships' blocks (except malleable iron and wooden blocks) used for lifting purposes and shall include

pin and sheaves, any shackle, eye, hook, becket or permanent attachment to any block

Marking.—Blocks shall be stamped with (*a*) Maker's name or trade mark; (*b*) Identification number; (*c*) Safe working load in tons

Safe Working Load—The S W L shall be the maximum load which in ordinary working can be safely lifted by the block In the case of single sheave blocks used singly or in combination the load on the pin or eye of the block shall not exceed half the test load under any conditions of working.

Factor of Safety—The factor of safety shall not exceed one-fifth of the calculated breaking load of the material or any part of the block This factor of safety is intended to allow for additional stress due to friction, acceleration of load and shock.

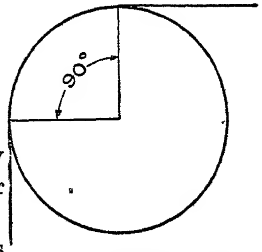
Test Load—All blocks to be tested by the application of the following loads without showing any deformation, visible cracks, flaws or defects.

Single sheave blocks	.. .. ..	4 times the S W.L.
Multiple sheave blocks	up to 20 tons,	2 times the S W L.
,, ,,	20 to 40 tons,	S W.L. +20 tons.
,, ,,	over 40 tons,	$1\frac{1}{2}$ times S W L.

Sheaves.—The diameter to be the outside measurement of the sheave. Pins to be secured to prevent rotation. Depth of groove to be not less than the diameter of the rope. Angle of flare of groove, 50° to 60°.

Where the angle of embrace is 90° or more it is recommended that the minimum diameter of the sheaves for various sizes of rope shall be as follows:—

Under 2″	wire.	10″ sheave.
2″ to $2\frac{1}{2}$″	,,	12″ ,,
$2\frac{1}{2}$″ to 3″	,,	14″ ,,
3″ to 4″	,,	16″ ,,
Over 4″	,,	18″ ,,



Angle of Embrace 90°.

The minimum diameter of sheaves for any other conditions should be not less than four times the circumference of the wire used.

All nuts to be securely locked and sheaves and swivel heads to be provided with sufficient lubrication.

Beckets to be capable of carrying at least half the load on any one sheave.

Shackles.—Shackles to be legibly stamped with their safe working load and their identification number.

Information as follows to be supplied when ordering cargo lifting blocks. Description of block Fittings. Number of sheaves Type of sheave. Size of rope. Safe working load. Remarks.

QUESTIONS.

1. Sketch a derrick and name the gear on it.

2. How would you go about putting the gear on a derrick and getting it upended ready for working cargo?

3 What is meant by the "parallelogram of forces"?

4. Draw the following to scale:—

Length of derrick, 50 feet.

From heel of derrick to span on the mast, 40 feet

Angle between derrick and mast, 30°.

Weight suspended from the end of the derrick, 3 tons

From your figure find the approximate thrust on the heel of the derrick and the strain on the span.

Ans.—3·8 and 1·85 tons.

5. The same derrick is lowered to make an angle of 60° with the mast. What will the relative thrust and strain be now?

Ans.—3·8 and 3·3 tons.

6. A span between two masts is formed by two pendants, one pendant makes an angle of 40° with the vertical and the other makes an angle of 60° with the vertical. A load of 6 tons is suspended from the span, find by construction the load on each pendant.

Ans—5·5 and 3·9 tons.

7. A span is formed by two pendants from two masts, one at an angle of 30°, the other at an angle of 80°, to the vertical. Find the tension on each arm of the span when supporting a weight of 4 tons.

Ans.—$2\frac{1}{4}$ and $4\frac{1}{4}$ tons.

8. A derrick at an angle of 50° is supported by a topping lift at an angle of 40° to a vertical mast. Find the thrust on the derrick and the tension on the lift when a weight of 6 tons is hanging from the head of the derrick.

Ans.—$3\frac{1}{2}$ and $4\frac{1}{2}$ tons.

9. From the following information construct a figure to scale and by means of triangles of forces find (1) the stress on the cargo gin; (2) the thrust on the derrick; (3) the tension on the span; (4) the load on the span block; (5) the load on the leading block at the heel of the derrick when given length of derrick 25 feet; heel to span block on mast 20 feet; length of span 18 feet; angle the fall makes at the heel block 92 degrees; weight to be lifted 10 tons, using a single wire fall.

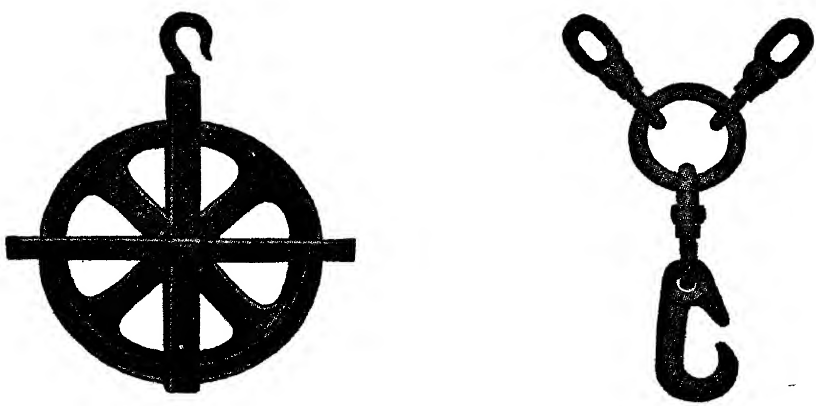
Ans. (1) Stress on gin block $18\frac{1}{4}$ tons.
(2) Thrust on derrick heel $22\frac{1}{4}$ tons.
(3) Tension on span 9 tons.
(4) Load on span block $13\frac{1}{2}$ tons.
(5) Load on heel block 14 tons.

10. What do you consider to be the best arrangement of derrick or derricks when loading or discharging a bag cargo?

11. Describe the cargo gear you would rig when loading (*a*) slings of goods weighing about 5 cwt.; (*b*) heavy goods weighing 1 ton per sling.

12. A beam weighing 30 cwt. is supported in slings attached to shackles on upper flange of beam and 12 feet apart. If the legs of the sling are 8 feet long, find the stress on each leg.

Ans. $22\frac{1}{2}$ cwt.



A Cargo Gin. A Cargo Hook.

Fig. 28.

CHAPTER XIII.

THE EFFECTS OF THE SCREW RACE UPON THE STEERING OF STEAMSHIPS.

THE turning effect of the rudder depends upon the force and direction at which the passing flow of water impinges on the rudder plate, already referred to under "Parallelogram of Forces," page 264.

The free flow aft of the water along the ship's side is interfered with in the vicinity of the rudder by the local currents set up by the revolving screw and the streamline form of the vessel. Experiments are still being carried out with balanced, semi-balanced and unbalanced rudders to discover the ideal streamline shape and the position and the method of their suspension, so that they may react in the most effective way to the actual flow of water in their immediate vicinity It is impossible to determine in practice the ultimate direction of this current as it is the resultant of a complicated spiral commotion set up by the rotating propeller, modified by the horizontal flow of water due to the steerage way of the ship, so that deductions arrived at by theoretical analysis are, more or less, of an empirical character.

The seaman is only concerned with the manoeuvring of his ship, her responsiveness to rudder action in turning to port or starboard when going ahead and going astern. The theorctical steering effect may not be exactly the same as that experienced in practice. The successful pilot finds out what the ship will do under stated conditions and then avoids, if possible, trying to make her do something else.

We shall discuss the steering forces under three heads:

I. The Wake Current.
II. The Transverse Thrust.
III. The Screw Race (*a*) Transverse Component; (*b*) Fore-and-aft Component.

I.—The Wake Current.

The Wake Current is the simplest to comprehend. Hold a flat piece of wood vertically in the water, pull it forward first edge on and then side on. Note the current effect, particularly when it is side on, and observe the hollow, or cavitation, behind the wood and how the

water swirls round the edges and follows up behind in an endeavour to fill the cavity This follow up is called the Wake Current ·

The same effect is produced by a vessel with or without a propeller when being towed. She drags "dead" water after her to fill up the hole caused by the volume she has displaced. This current is strongest at the surface and gradually diminishes to zero strength at the keel level; it is non-existent when the vessel is stopped and increases in velocity as the ship's speed increases The wake current is more pronounced in vessels of full form than in those of fine lines This is the chief reason why flat-bottomed, square-sterned barges are difficult to steer as the wake current following up behind is strong and neutralises more or less the effect of the flow aft due to the vessel's headway.

Effect.—

Going ahead—The wake current reduces the steering power of the rudder.

Going astern—No effect; it does not exist at the stern.

II.—Transverse Thrust.

The obliquity of the blades sets up a current which may be resolved into a transverse component and a fore-and-aft component; the transverse force or thrust exerted by the screw is, however, small in comparison to the fore-and-aft force which drives the ship ahead.

Effect of Right-handed Propeller.—

Going ahead—Stern cants to starboard.

Going astern—Stern cants to port briskly.

The athwarthship component of the obliquity of the screw does not account for the slewing of the stern as, in theory, the thrust to one side should be equal to the thrust to the other side because the upper and lower blades pass across equally each way in the course of a revolution, the pressure low down being practically equal and opposite to the pressure high up.

But the propeller churns and breaks up the water near the surface to a greater extent than deeper down, with the result that the lower blades cut through more solid water and have to overcome greater resistance than the upper ones. Think of a propeller half immersed The upper half cuts through air, the lower half through water, and the difference of these transverse pressures slews the stern to starboard when going ahead, but more briskly to port when going astern, as the forward flow of water from the propeller washes up against the hull and retards the sternway of the ship, thus reducing the fore-and-aft component relatively to the transverse component.

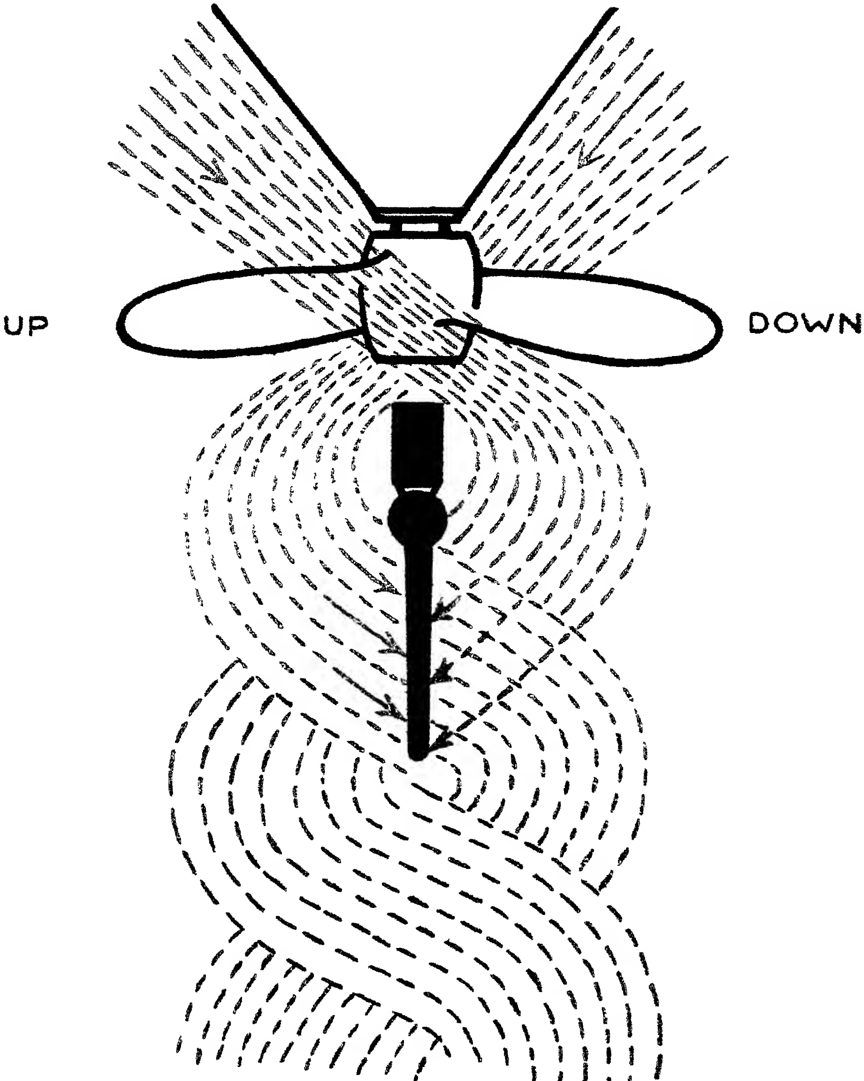


FIG 1

SCREW RACE—RIGHT HANDED PROPELLER GOING AHEAD

Green lines represent the flow of the starboard water—
Red lines the flow of port water.

III.—The Screw Race.

The screw worms its way through the water and, in doing so, creates two spiral currents which corkscrew or curl sharply round each other and criss-cross at different levels in the screw aperture whilst, at the same time, the body of rotating water is driven astern by the thrust impulse imparted to it by the after side of the blades when the engines are going ahead. The twisting particles of water may be resolved into two components, transverse and fore and aft.

Figure 1 is an effort to illustrate the spiral flow of the layers of water acting against the rudder. Imagine the port blades of the propeller to be coming up and the starboard blades to be going down, as they do when going ahead with a right-handed screw

The downstroke to starboard induces and urges the water to pass diagonally across the aperture from starboard to port under the boss and to curl sharply upwards and back again, washing against the port upper half of the rudder in its endeavour to get back to the starboard side of the ship. That is to say, the water enters on the starboard side, crosses to port below the boss, curls up again and is discharged higher up against the top half of the port side of the rudder.

This transverse component acting on the rudder pushes the stern to starboard.

Simultaneously, the upstroke to port induces and throws the water diagonally across the aperture from port to starboard above the boss, the spiral impulse causing the water to curl sharply downwards and back again and to wash against the starboard lower half of the rudder in its endeavour to get back to its port side of the ship.

That is to say, the water enters on the port side, squelches across to starboard above the boss, and is discharged against the starboard side of the rudder low down when finding its way back to port.

This tranverse component acting on the rudder pushes the stern to port.

So here we have a double transverse effect acting simultaneously on opposite sides of the rudder, a flow of water acting on its starboard side low down and another flow acting on its port side high up; but the deeper flow acting on the starboard lower half predominates and urges the ship's stern to port.

The rotary effect of the screw race has been demonstrated by an interesting experiment, in which a rudder was horizontally divided into two parts—an upper and lower half—each part being free to move in response to any influences. When the screw (right-handed) was

working ahead, the lower half was found to be inclined nearly 10° to port, and the upper half at a slightly less angle to starboard. A whole undivided rudder, which was free to move in either direction, was found—when the screw was working ahead—to incline a little to port.

(b) *Fore-and-aft Component.*—The after face of the blades is the pressure surface of the screw when going ahead. The particles of water are pushed astern past the rudder and give an underway steering effect immediately the engines are started and before the ship gathers headway.

Screw Race Effect—

Going ahead—(a) Transverse component cants stern to port.
(b) Fore-and-aft component gives the steering effect of headway.

Going astern—(a) Transverse component cants stern to starboard
(b) Fore-and-aft component gives steering effect of sternway.

SUMMARY WITH RUDDER AMIDSHIPS

	Effect when starting from rest		Effect when going	
	Ahead	Astern	Ahead	Astern
I. Wake Current	No effect Current non-existent	No effect	Reduces steering power Weakly at first but strongly as ship gathers headway	No effect
II. Transverse Thrust	Stern to starboard Strong	Stern to port Strong	Stern to starboard Fairly strong	Stern to port Strong
III. Screw Race (a) Transverse Action	Stern to port Weak	Stern to starboard Weak	Stern to port Weak	Stern to starboard Weak
(b) Fore-and-aft Action	Gives steering effect of headway	of sternway	Gives steering effect of headway	of sternway
Probable Resultant of I., II., III., acting together	Head swings to port Can be counteracted by rudder if desired	Head goes to starboard Cannot be counteracted by rudder	Head goes to port Can be counteracted by rudder if desired	Head goes to starboard Cannot, as a rule, be counteracted by rudder unless considerable sternway is gathered

The **screw** exerts its greatest turning effect when the engines are going **slow ahead** or **full astern**, the radius of the ship's turning circle increasing with her speed through the water.

The churning of the water is greatest when starting the engines from rest, particularly when going astern, and especially so when reversing from full ahead to full astern. The excessive vibration then felt throughout the ship is due to cavitation, the blades following each other in quick succession into the same "hole" before the water has time to effectively fill the cavity.

In view of the importance of reversing the engines when going ahead, the following extracts are taken from the Report of a Committee of the British Association appointed to discover the best rules for the guidance of ships' captains in endeavouring to avoid collisions (see *White's Naval Architecture*)

"The distance required by a screw steamer to bring herself to rest from full speed by a reversal of her screw . . . generally lies between four and six times the ship's length. It is to be borne in mind that it is to the behaviour of the ship during this interval that the following remarks apply:—

"It is found an invariable rule that during the interval in which a ship is stopping herself by the reversal of her screw, the rudder produces none of its usual effects to turn the ship; but that under these circumstances the effect of the rudder, such as it is, is to turn the ship in the opposite direction from that in which she would turn if the screw were going ahead. The magnitude of this reverse effect of the rudder is always feeble, and is different for different ships, and even for the same ship under different conditions of lading.

"It also appears from the trials that, owing to the feeble influence of the rudder over the ship during the interval in which she is stopping, she is then at the mercy of any other influences that may act upon her. Thus the wind, which always exerts an influence to turn the stem or forward end of the ship into the wind, but which influence is usually well under control of the rudder, may, when the screw is reversed, become paramount, and cause the ship to turn in a direction the very opposite of that which is desired. Also the reversed screw will exercise an influence which increases as the ship's way is diminished, to turn the ship to starboard or port, according as it is right or left-handed; this being particularly the case when the ships are in light draught.

"These several influences, the reversed effect of the rudder, the effect of the wind, and the action of the screw, will determine

the course the ship takes during the interval of stopping They may balance, in which case the ship will go straight on; or any one of the three may predominate and determine the course of the ship. The utmost effect of these influences when they all act in conjunction—as when the screw is right-handed, the helm starboarded, and the wind on the starboard side—is small as compared with the influence of the rudder as it acts when the ship is steaming ahead."

SHIP WITH HEADWAY, FULL AHEAD TO FULL ASTERN.

Discuss the Steering Effect of Propeller and Rudder.

This case may arise suddenly through force of circumstances to avoid colliding with something close ahead. The turmoil in the propeller aperture is rather confused but is something on the following lines.

The normal current flowing aft past the rudder is interrupted by the reversed screw (i) discharging water forward in opposition to it, and (ii) by inducing a forward flow which acts on the after side of the rudder. These two forces gain strength as the screw continues to reverse and eventually they predominate and swamp the normal flow due to headway, but at first the turning effect of the rudder is doubtful and it should be kept amidships, for then it won't be on the wrong side, but when the vessel gets sternway it should be angled to one side or the other as required. One thing is certain to happen at first, viz., the ship's head will fall off to starboard.

The distance the ship will carry her headway is perhaps of more importance in an emergency than the arc her head will describe when the engines are rung from full ahead to full astern. It depends on the ship's initial speed. The average 10-knot cargo vessel of 8000 tons deadweight will probably bring up in about six times her length, and if going half speed this distance will be reduced to about one-half. It is interesting to note that when the backwash from the reversing propeller reaches forward to about the navigating bridge the vessel's headway is practically stopped, assuming the bridge to be a little forward of amidships as it usually is. This approximation is a guide when stopping the ship at night time for any purpose and no objects in sight.

To turn a single screw steamship short round.—A consideration of what has already been stated will show that a steamer with a right-handed propeller can be turned more easily with her head going to

starboard than in the other direction. When necessary to turn short round put the rudder to starboard, and the engines full speed ahead. The screw race will press against the rudder, even if the vessel has no headway, and she will cant to starboard. Before she gathers too much headway the engines should be reversed to full speed astern, the helm being shifted accordingly so as to obtain the benefit of the suction current. Before she gathers too much sternway go full speed ahead again with rudder to starboard and so on, alternately, until round.

It is advisable to have an anchor ready for dropping when turning short round in narrow channels and to know that there is sufficient depth of water when manoeuvring close to the banks.

TWIN SCREWS

The effects of twin screw propellers are not so complicated as those of single screws. It is only necessary to take into account (1st) the current caused by the screw, and to consider whether it is a discharge current acting against the fore side of the rudder, or whether it is a suction current drawn in against its after-side; (2nd) the transverse thrust of the screws.

As the screws revolve in opposite directions* when both are going ahead at the same speed, there should not be any turning effect from the transverse thrust of the screws, and if the helm is ported or starboarded they will assist the action of the rudder Also when the screws are going astern, the current drawn in by the propellers acts on the after-side of the rudder, and if the ship is also moving astern they assist the action of the rudder.

To turn a twin screw steamship short round.—This is done by going ahead on one and astern on the other; the bow of the ship then turns towards that side on which the screw is going astern. By regulating the speeds of the propellers so as to prevent the vessel getting headway, the steamer can be made to turn round in her own length. When turning short round in this way the helm should be kept amidships

If the starboard screw is right-handed and the port one left-handed, the transverse thrust of both screws will assist in turning the ship short round in either direction.

TURNING CIRCLES.

Very meagre information seems to be available regarding the turning circles of merchant ships and the time taken by them to

*The starboard one is generally right-handed and the port one left-handed.

complete a round turn, probably owing to the fact that much depends upon the trim and load displacement of the ship. The average time to complete the first turn works out at about 8 minutes. In the case of a vessel of 2000 tons on trials she turned through 180° in 3 minutes and 360° in 7½ minutes, the initial speed was 14 knots which was reduced to about 7 knots when the circle was being completed, the diameter of her turning circle worked out at 6 times the length of the ship.

The trials of a Bibby liner fitted with an Oertz rudder by the Marine Navigation Company, London, worked out as follows:—

Turning circles with rudder hard over. Speed 11½ knots approximately.

	Turning to port	Turning to starboard
¼ circle	1m 55s	1m 45s
½ ,,	3m 40s	3m 32s
¾ ,,	5m 36s	5m 37s
Full circle	7m 46s	7m 45s

Average time to throw the rudder from hard over to hard over, 20 seconds.

SHIP HANDLING.

1. What would you particularly look to in seeing if all was ready in a steamship for going out of dock and proceeding to sea?

Engine-room telegraph, steam whistle or siren, steam steering gear, winches, etc.; also see there were no boats, lighters, lines, etc., about the stern likely to foul the propeller. If possible I would get the derricks lowered and secured, the hatches on and battened down. Also I would have all lamps trimmed, patent log ready for use, hand lead line and heaving lines handy, fenders ready, mooring ropes all clear for coming in or carrying along. Charts and all gear ready in the chartroom. Everything in order on the bridge.

2. What information does a pilot require when he comes on board?

Full details regarding any special features of the ship, particularly her steering qualities and the working of her engines, also her power when they are going astern. The draft of water. The deviation of the compass.

3. What effect has a right-handed propeller on a steamer's course when going ahead with helm amidships; also when going astern?

Her course would be directed to port when going ahead, and her head would cant to starboard when going astern.

4. How does a steamer cant when her engines are started ahead or astern—no wind or tide?

Assuming that she has a right-handed propeller: when going ahead, her stern will cant to starboard and her head to port. When going astern her stern will cant to port and her head to starboard. This turning effect is caused by the transverse thrust of the propeller. It is greatest when the engines are first started, diminishing as the vessel gathers way, but is not entirely lost.

5. How would you turn a steamer short round?

Rudder for starboard swing and put the engines full speed ahead. As she gathers headway, full speed astern, and rudder amidships. Carry on in this way until she is round.

6 Is the propeller in a single screw steamer right-handed or left-handed?

Generally right-handed. I should always assume it to be so unless the examiner distinctly mentioned a left-handed one.

7. A man falls overboard; what would you do?

Stop the engines, throw him a life-buoy, put the rudder hard over to the side from which he fell, hand aloft to watch him Start up the engines again and steam right round in a circle, meantime getting the emergency boat swung out, manned and ready for lowering. When the ship is heading for the man steady the helm, ease the engines and get as close to him as possible, stop the ship, drop the boat and pick him up.

8. What would you do if a man fell overboard in heavy weather?

Heave him a life-buoy. Stop the engines. Send a man aloft to watch him if necessary. Manoeuvre the ship to windward of the man, at the same time getting ready a boat which will be a lee one when you are in position for lowering. Spread oil to make a smooth. Heave the ship to, man the boat and lower away. Steam down to leeward, again spreading oil, and make a lee for the boat. Have a boatrope fore and aft with men to tend it ready for the boat as she comes alongside. Have good men at the falls, watch a chance to hook on, get her up again as quickly as possible.

9. In hazy weather you discover land ahead and on each side. What action would you take?

Come full astern on the engines. Turn the ship short round and steam out on a course opposite to that on which I came in. Take frequent soundings and proceed with caution.

10. What would you do if you sighted a fog bank right ahead?

Reduce to a moderate speed. Station a hand on the look-out. When I enter the fog make the fog signal prescribed for steam vessels under way with way upon them.

11. You are proceeding at a moderate speed. You have a light wind right aft. A blast on a foghorn is heard fine on the port bow What would you do?

Stop my engines and navigate with extreme caution. It is a vessel on the starboard tack crossing. Keep a sharp look-out for her. It may be necessary to alter my course or ring full ahead or full astern on the engines.

If we came within sight of one another and I had to alter my course or go full speed astern to clear her, I should indicate my action by a short blast or blasts on the whistle or siren according to Article 28.

12 What is meant by a vessel being **wind-rode**?

When a vessel at anchor is riding head to wind she is said to be "wind-rode."

13 What is meant by a vessel being **tide-rode**?

When she is lying head to tide she is said to be "tide-rode."

14 When is a vessel said to be **riding weather tide**?

When she is at anchor, and the wind is against the tide.

15 When is she said to be **riding lee tide**?

When the wind and tide are in the same direction.

16 When coming to an anchor in fine weather, and only intending to stay there for a short time; how much cable would you give her?

If there was no tide, four times the depth of water would be enough. In a tideway I should give her more, the actual amount depending on the strength of the tide and the nature of the bottom. In good holding ground I should not want so much as in ground where the holding was poor.

17 In what direction would your anchor lie if you were riding head to wind and tide?

About a point on the bow. I should keep it there by giving her a small sheer with the rudder away from the anchor. If the port anchor were down, wheel to starboard would do it. If the starboard anchor were down, turn the wheel to port.

18 Suppose in a strong wind or tide she "yawed" about, frequently breaking her sheer; what would you do?

Have a man at the wheel, and steer her as if under way.

19 What is the best position to have the shackles when you are moored with two anchors in a tideway?

They should be where they would be handy to get at in the event of having to unshackle for the purpose of clearing hawse. Close abaft the compressor or windlass would be a good place. There would then not be much cable to pass round.

20. Why are ships moored with two anchors?

Because when moored with two anchors placed in opposite directions they do not cover so much ground when swinging at each turn of the tide. They would ride to one anchor on the flood, turn round practically in their own length, and ride to the other on the ebb

21. In what direction should the anchors lie when moored in a tideway?

In the direction of the ebb and flow of the tide The one to which the vessel was riding should be a little on one bow, and the other one fine on the opposite quarter.

22. How often does a vessel swing when she is anchored or moored in a tideway?

She swings at every turn of the tide in moderate weather. That is at intervals which will average about $6\frac{1}{4}$ hours.

23. Does it matter *which way* she swings?

Yes. She must always swing round **on the same** side of her two anchors. If she does not, she is liable to get turns in her cables.

24. What would you do to ensure her swinging the right way?

Give her a sheer with the helm just before slack water. The new tide would then catch her on the quarter and swing her round in the same direction in which I had sheered her.

25. Suppose through failing to tend her, or for any other reason she swung round the wrong way; what would happen?

The first swing would cause a cross in the cables, the second swing would produce an elbow, and if she swung round the wrong way three times there would be a round turn.

26. Having got a turn in the cables, how would you take it out; or in other words how would you "clear hawse"?

At slack water I would lash the two cables securely together, below the turns if possible. Lead a good wire through the forecastle-head warping chock and shackle it on to the cable I was not riding by. Heave it tight and make it well fast. Reverse the windlass, unshackle the cable, and take the turns out by passing the end round the cable I was riding to. Shackle on again, heave tight, and screw the windlass up Take off the lashing and wire.

27 What would your duties be, as second mate, when keeping anchor watch at night?

To see that the Regulation lights were burning brightly, keep a good look-out and specially watch for any signs of the vessel dragging her anchor. Be sure that the other anchor was all clear and ready in case of emergency. See that no unauthorised boats come alongside the ship. Keep the other members of the anchor watch handy on deck. Carefully attend to any standing orders.

28. How would you know if the ship was dragging her anchor?

By watching the bearing of two fixed lights or objects in line. Beam bearings are the best. If they change, the ship is dragging.

By dropping the deep sea lead on to the bottom, and noting if it trails ahead of the ship.

By putting my hand on the cable before the windlass. If she was driving I should feel the vibration caused by the anchor dragging along the bottom. Should also listen for any *sound* of the anchor dragging by applying my ear to the cable. Both these methods, however, may be deceptive because vibration and sound are often caused by the cable moving on hard ground even though the anchor is holding well.

Also, in soft mud the anchor might drag without causing any vibration or sound.

29. What would you do if you found the anchor was dragging?

Give her more cable. If I saw that it was urgent, I should not hesitate to let go the second anchor. Send a message immediately to my senior officer or to the master.

30. How would you carry out a kedge and warp in a boat?

If I was carrying it out to windward or against the tide I should coil or fake the whole length of the warp down in the boat clear for

running. Lower the kedge down into the boat, landing the crown and arms on to a plank lashed across the gunwales well aft, and having the stock in a vertical position over the stern. Bend the end of the warp on to the kedge. Pull the boat out to the desired position, be sure that the warp is clear, and drop the kedge. This is best done by turning or sliding it over the quarter. It is much easier than topping it up over the stern, and less likely to result in a foul anchor. I should pay the warp out from the boat as I pulled back to the ship and pass the end on board. Should not forget to buoy the anchor before dropping it.

When carrying a kedge out to leeward or with the tide, after making the warp fast to it, I should hang it over the stern by means of a sliprope, but instead of coiling the whole of the warp down in the boat should take only a few fathoms to slack away if necessary, making them pay it out from on board the ship as I pulled away.

This would save me the work of dragging the floating warp back to the ship against the wind or tide; in a ship's boat it might not be possible to do it.

31. What is the length of the buoy rope, and how should it be made fast to the anchor?

It must be long enough for the buoy to float at high water, and to ensure that the buoy is not run under in a strong tide.

It should be made fast at the crown of the anchor by means of a clove hitch with one part on each side of the shank, and finished off with two half hitches.

32. What is the object of buoying the anchor?

To mark its position, and to provide a means of recovering it if the warp should be carried away. The buoy rope, of course, must be good enough for the job.

33. You come to anchor in bad holding ground. What precaution would you take to ensure against dragging?

Give her a greater length of cable than I should if the holding ground was good.

34. In that case, what would you do at slack water if there was no wind?

Heave in the cable until short. When the vessel swings with the new tide veer away again until I am riding to the required length.

35. Coming in against the ebb tide, how would you make fast between two mooring buoys, head out?

If the tide was not too strong I should steam slowly up past the lower buoy, keeping both buoys on my port side. When far enough ahead run a good line from my port quarter on to the upper buoy. Make it fast to the bitts or take it to a good winch ready for heaving close up. The ship will then swing round with the tide. A little time would be saved by going alternately astern and ahead on the engines. When swung, make her well fast by the stern to the upper buoy. Get my cable or some good headlines on to the lower buoy.

If there was much tide I should steam up to the lower buoy, run some good headlines to it or shackle my cable on, and wait for slack water. When the new tide made, the ship would swing round to it I could then get my stern moorings on to the upper buoy.

BERTHING, ETC.

It is not possible to give definite instructions for bringing a steamer alongside a wharf, dock, or pier, which will apply to all cases. Much will depend upon local conditions, set of tides or currents, conveniences available for use in the shape of buoys, dolphins, etc. The following general suggestions should, however, be noted, and will apply to most cases:—

Slack water is the best time—the stronger the tide or current the more difficult it will be.

If there is any tide or current running the vessel should be stem on to it. She should be kept nearly parallel with the wharf, with the bow slightly canted towards it, and gradually brought alongside.

If the wind or tide sets the vessel towards the wharf, lines must be run out to buoys if available, so as to ease her down to her berth. If no buoy or dolphin is available take the vessel a little ahead of her berth and drop the off-shore anchor, and ease her alongside with the cable.

In any case, when a convenient distance from the shore and stem on to the tide, run a spring out ahead from the bow, and also breastropes from the bow and stern. Heave in enough of the spring to keep her from dropping astern of her berth, and then heave her steadily in with the breastropes. Remember that heaving in a bow breastrope will tend to make the stern go out unless there is a stern breastrope to prevent it, and *vice-versa*. The vessel must only be allowed to cant very slightly towards the shore. The helm can be used when stem on to the tide

just as if under way, and the ship sheered towards or away from the shore as may be necessary.

Note carefully if there are any overhanging obstructions likely to foul the ship's rigging, davits, bridge, etc , and take corresponding precautions. (See detailed questions further on.)

Getting away from Alongside a Wharf, Dock, Etc.

If the vessel is stem on to the tide.—Have a spring from aft made fast to the wharf well forward, and a breastrope from the bow. Cast off the moorings, and the weight coming on the spring her bow will cant out, use the rudder to assist in canting ship's head as desired. When the bow cants out keep a check on the breastrope, which will bring the stern out, when clear, the engines can, if necessary, be used.

If the vessel is stern on to the tide.—Have the spring from forward, the breastrope from aft, and bring her out stern first

Care must be taken not to use the engines until clear, and also to allow for the effect they may have in bringing her stern in or out.

Coming Alongside a Wharf, Docking, Etc.

1. **You are coming up a river on the flood tide,** how would you go alongside a wharf?

Have my anchors clear and my heaving lines, fenders, and mooring ropes all ready for use. When a little way past my berth turn my ship round and stem the tide. Steam slowly towards the wharf. Give her a slight cant in as I approached it, using my engines as necessary. Get a good headline ashore and make it fast. When the weight comes on it she will drop alongside. See that she is properly moored.

2. **Coming up on the flood,** how would you get alongside if there was a strong wind blowing across the river directly on to the wharf?

Round her to and stem the tide. Steam slowly into a good weatherly position ahead of my berth. Let go my offshore anchor. Run a good headline ashore on to the wharf and make it fast. Ease away my cable. The weight will gradually come on to the rope, and she will drop alongside. Mind my fenders.

3. How would you get alongside a wharf if you were coming up a river on the ebb tide?

Steam slowly up towards the wharf, having just enough way to stem the tide and carry me over the ground as I approach it. When

abreast of my berth give her head a slight cant in and stop my engines. Run a good headline ashore and make it fast, having a second one all ready. As the weight comes on the headline she will drop alongside with the tide. Make her well fast.

4. What precautions would you take if the tide was very strong?

Steam up a little ahead of my berth and drop my offshore anchor. Run a good headline ashore. Ease her back alongside with the cable and headrope. Pay particular attention to my fenders and moorings.

5. **What general precautions** would you take as regards moorings, etc., when lying at a wharf?

See that my headlines led well ahead, and my sternlines led well astern, and that I had a good drift on my backsprings. Have good breastropes from my outside bow and quarter. A paunch mat on my stem and other chafing gear where it was necessary. Tend my breastropes very carefully if there was much rise and fall of tide, easing them and tightening them up again as required. Should not forget my gangway. See that I had suitable fenders and that they were properly placed. In addition to my ordinary moorings should have a stout wire ready both forward and aft in case it came on to blow hard. When no cargo was being worked should see that a good watch was kept throughout the night. Have an officer on active duty if conditions demanded it.

6. **You have arrived off a dock** on the top of high water; how will you get in?

Steam slowly towards the pierhead making allowance for the wind by keeping in a good weatherly position. Have my anchors ready for letting go if necessary, also all lines and fenders handy. Give her a cant in and straighten her up as I approach the entrance. There will be no need to go alongside before entering the locks. Run a good line ashore on to the pierheads from each bow as soon as possible, also one from each quarter when near enough, weather ones first. Come slowly ahead paying attention to dock-master's orders. Pierhead men will attend to my lines ashore. Look out for tugs, barges and other small craft (Fig. 2.

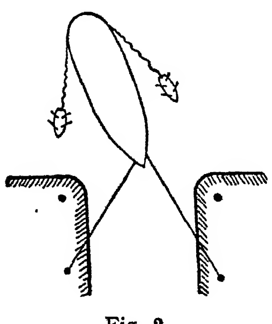


Fig. 2.

7. You are coming up a river, on the flood. How would you dock your ship with the tide running right across the entrance?

I would turn round and stem the tide. Come alongside the lower pierhead (A) and get a line ashore from my inside bow. After getting alongside and if no tug available I would run a line from the outside quarter to the opposite knuckle (B) to heave her stern up against the tide. Engines ahead and check round the knuckle using bow line as required and heaving on the quarter rope.

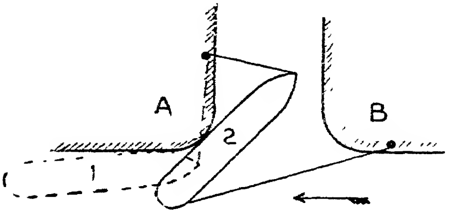


Fig 3

Alternative method. If the tide is strong, come alongside at upper side of entrance (B), get port quarter and bow ropes ashore, then drop astern, first using quarter rope to check her in to the entrance stern first, then the bow rope to keep the vessel from being swept too far round by the tide.

8 Coming up a river you have arrived outside a dock with the ebb tide coming down but are just in time to get in. How would you dock her?

Give her a cant in under very easy steam, run a good line ashore from my inside bow; and drop gently alongside the pierhead. Should not waste any time, but should be careful not to do any damage. With the exception that I should not turn her round before coming alongside, the procedure would be the same as in the answer to the last question.

9. You are anchored in a river below a dock entrance on the flood tide. Several other vessels are anchored astern of you. How would you get into the dock?

Lift my anchor and drop up the river with the tide. Give my ship a little way with the engines and sheer her over towards the river bank so that she will not foul any of the vessels astern. Avoid passing in between them unless I had plenty of room. When clear of them all, and above the dock entrance, steam slowly towards the pierhead, sheer in gradually and lay her alongside the up-river knuckle. Enter the dock as before.

10. What would you do if there was not enough water for you to go round outside them?

If I could pick a clear passage should lift my anchor, turn her round, and steam slowly between them. If it was too risky to do that, it would also be too risky to drop or dredge her up through them. That being the case I should wait for slack water I could then get under way and approach the entrance direct from the position where I was at anchor.

11. What do you mean by "dropping" or "dredging" her up?

"Dropping" her up is done by *lifting* the anchor clear of the ground and allowing her to drift up with the tide.

"Dredging" her up is done by *leaving* the anchor on the ground but heaving the cable so short that the anchor will not hold. She then drags or "dredges" it along the bottom.

Dropping or dredging her down is exactly the same thing, but, of course, is done on the ebb tide.

12. Is the helm of any use when dropping or dredging a ship in a tideway?

When "dropping" a vessel up or down she is simply drifting with the tide and has no way through the water; the helm is consequently of no use.

When "dredging" her the anchor retards her speed over the ground, bringing her stem on to the tide and causing the water to pass by her. The helm will then have the same effect and can be used in the same way as if the vessel was going ahead.

13. Which knuckle do you work round when entering a dock?

The lee one, if the tide is not too strong.

14. How would you enter a dock, no tug and no steam on the main engines?

Presuming my ship to be lying alongside in close proximity to the entrance I should pass a good rope along from the inside quarter and make it fast on the knuckle. Have a good check rope from the inside bow. Spring the ship ahead with the quarter rope and when half her length or a little more is past the knuckle head apply the check and bring her head into the entrance. Heave her along into the lock.

15 You are coming up a river in a large steamer. How will you place her alongside a wharf on your port side; you have the ebb tide setting down on your starboard bow; no tugs?

Steam up a little way ahead of my berth, keeping far enough out to prevent the tide setting me heavily on to the wharf. Stop the engines. Let go my off-shore anchor Get a line ashore from the port bow. Slack away the cable and lay her gently alongside. If when coming alongside she is inclined to bump her stern on the wharf, I should remember that she will still answer the helm. Rudder to port would tend to keep her stern off The rudder would be useful throughout the whole job of berthing her. When safely alongside, slack the cable down and make her well fast.

16 You are about to enter a lock. Stream across the entrance. The ship will not answer her helm. What would you do?

Increase speed to get steerage way. Reduce again as soon as possible. Come astern to check her if necessary.

Getting Under Way from Anchorage, Buoys, Wharves, etc.

17. What preparations would be necessary, and how would you get under way, when lying at single anchor in an open roadstead?

Notify the engineers that steam for the main engines would be required at a certain time. Have all hatches battened down, derricks secured, and all deck fittings and gear prepared for sea. See that steam was on the windlass and steering gear and that they were in good working order. Put the helm over both ways. Test whistle and engine room telegraphs, also other telegraphs and speaking tubes. Have lead line handy and patent log ready for streaming. Charts out and sailing directions handy. Officers and crew at their proper stations. All shore people ashore. Search for stowaways. If at night see that my navigation lights and all other necessary lights were ready. Get under way by heaving the anchor up.

18. You are riding to two anchors in an open roadstead in bad weather. How would you get under way?

Steam slowly ahead towards my anchors and heave in some of the cable on both of them. Screw one of my cables up, say the port one. Sheer her over towards my starboard anchor which will now be the lee one, and heave it right up, stopping my engines when necessary, as the

starboard anchor is broken out she will drop back a little to the port cable. Go easy ahead again to ease the strain on it and heave the port anchor right up. See that the windlass is well screwed up and that all is in good order forward as I proceed to sea.

19. You are in a river moored to a buoy with your cable. The tide is on the flood. How would you get under way and proceed to sea?

Put a good slip rope on to the buoy and heave it tight. Reeve a 4-inch line through the ring on the buoy, bend it on to the chain and heave on it to give the men a little slack Get the chain adrift from the buoy, shackle it on to the anchor, and see it all clear for letting go if necessary. Go slow ahead, take the slip rope in, and proceed down the river.

20. You are moored to a buoy with your cable on the ebb tide How would you get under way and proceed to sea?

Put a good slip rope on to the buoy, heave it tight, get the cable adrift from the buoy and shackle it on to the anchor again, seeing all clear as before. Let go my slip rope, turn her round with the engines.

21. How would you manage if there was not enough room in the river to turn her round with the engines?

Run a good wire out from aft on to the buoy, heave it tight and make fast. Put a good slip rope on to the buoy from the forecastle-head to hold the ship for the time being. Unshackle my cable and put it back on the anchor, seeing it all clear for letting go if required. Sheer her away from the wire and let go the slip rope (Position 2). She will then swing round to the wire with her head down the river. Let go the wire from the buoy (Position 3), haul it in and proceed (Fig. 4).

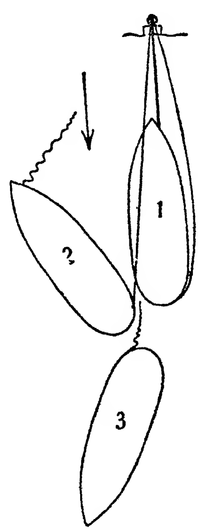


Fig. 4.

22. You are riding to your port anchor stern to seaward in a narrow river at slack water. How would you get under way and go to sea?

Heave the anchor up, turn her round with the engines, steam down the river.

Another way would be to heave in some of the cable, go slowly ahead passing the anchor on my port side with rudder to port and keeping a little strain on the cable, steam slowly round the anchor until I was heading down the river Stop the engines, lift the anchor, and proceed.

23 You are lying in a tideway moored to two anchors. How would you get under way?

Pay out on the cable ahead of me and drop back and pick up the anchor I am not riding to. I could then steam ahead to ease the strain on the cable and windlass and heave the other anchor up. I am then "under way."

24. How would you get under way when lying alongside a wharf head down a river on the flood tide?

Keep a good backspring fast from my inside quarter, also a forward breastrope. Take in all my other moorings. When ready, let go my forward breastrope and haul it in The tide on my inside bow will cant her head out. Go ahead on my engines, heave away on my after backspring, finally letting it go and hauling it in (Fig 5).

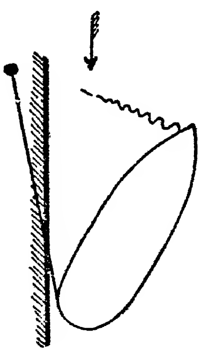


Fig. 5

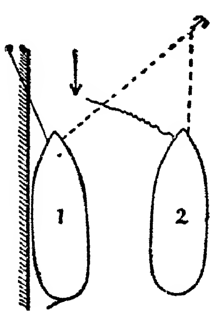


Fig. 6.

25. How would you get under way from a wharf when lying head to tide, your off-shore anchor being down and bearing 2 or 3 points on the bow?

Run a good headline out from my inside bow on to the wharf, keep a good forward breastrope out and take in all my other moorings. When all ready, let go my breastrope and haul it in. Ease away on my headline and let the ship swing out from the wharf and lie to the anchor (Position 2, Fig. 6). Haul my headline in. Heave the anchor up.

26. You are moored port side to a wharf on the flood tide which is coming up under your stern How would you get away and proceed to sea?

Leave my forward backspring out, also my after breastrope and take in all my other moorings (Fig 7), the ship will then forge ahead a little until held by the backspring. When ready, let go my breastrope

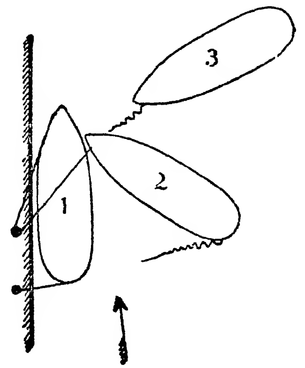


Fig. 7.

and haul it in, the tide on my inside (port) quarter will then throw her stern out (Position 2). When well canted out, say at right angles to the wharf, let go the backspring and come full astern on the engines (Position 3). Turn her short round, and proceed

27. What would you do if there was not enough room to turn her round with the engines?

Let go my breastrope, and when she was **well** canted out as before, let go the backspring and come astern clear of the wharf. Stop the engines and let go my port anchor. She will then swing round to it with her head down the river. Heave the anchor up and steam away.

28. You are moored starboard side to a wharf. How would you get away when lying stern on to the tide?

Keep a good backspring out from my inside bow, also an after breastrope. Take in all my other moorings. When ready, let go my breastrope and haul it in. The tide on my inside quarter will soon cant her stern out. When canted far enough, come astern on my engines, let go the backspring and heave it in.

29 How would you manage if your off-shore anchor was down bearing about 3 points on the bow?

Get away from the wharf in just the same way as before. When canted far enough out, come full speed astern on the engines and heave the anchor up at the same time If she swings right round and stems the tide before the anchor is up no harm will be done.

30 Why not work your way along, and heave the anchor up before leaving the wharf?

Because if I did so I might get my stern hard on the wharf as I hove away on the cable Some damage might then be done to the ship or to the wharf Cranes have been knocked over and other gear carried away by attempting this method.

31 You are moored to a wharf with the *tide astern of you*. A vessel is lying close ahead of you How would you get away?

Run a good wire backspring out from my inside bow, carry it well aft along the wharf, and drop the eye over a mooring post; heave it well tight and make fast. Keep my after breastrope fast and take in all my other moorings. When ready, let go my breastrope and haul it in. When her stern is canted well out come full speed astern on the engines When clear of the wharf, let go my backspring and haul it in (Fig 8)

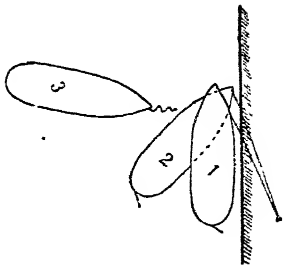


Fig 8.

32 From what part of the ship would you pass out your wire backspring?

From my "shoulder pipe" or my "warping chock" on the forecastle-head.

33. You are moored starboard side to a wharf, no tide, but the wind blowing directly across the river on to the wharf. How would you get away?

If the wind were light I should run a good wire backspring out from my inside bow, put it over a post well aft along the wharf, heave it well tight and make it fast. Go slow ahead on my engines with the rudder to starboard, and when the backspring has got the weight, increase gradually to full speed if necessary. When her stern is canted out far enough, rudder to port and come full speed astern on the engines. Heave away on the backspring, finally letting it go and hauling it in.

If the wind were strong I should have to run a good line out to windward to a buoy or dolphin to heave her head off the wharf. Failing this, a pull off with a tug would do. When her head was hove out or canted out far enough, and everything was all clear, go ahead on the engines.

A light ship having no outside assistance would have to remain where she was until conditions were more favourable.

34. When a steamer is light and trimmed by the stern, would she steer best with the wind on her port or on her starboard side, and for what reason?

She would steer best with the wind on her port side. The side thrust of the propeller tends to cant her head to port; the wind on the port side has the opposite effect, and more or less counteracts it.

35. How would you bring a ship out of dock stern first, wind up the river and not much room?

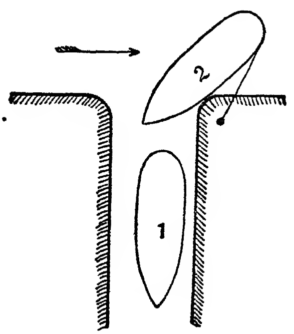


Fig. 9.

Come astern slowly through the locks, pass a quarter rope ashore on the lee knuckle of the lock to check her close round the corner as she comes astern, if there is not enough room to make a wider sweep into the river.

MANAGEMENT OF STEAM VESSELS AT ANCHOR.

Obviously the ultimate aim is to minimise as much as possible the danger of dragging: First, by keeping the anchor clear; and secondly, when there is risk of the ship dragging her anchor, owing to strong winds or tides or bad holding ground, to so manage the vessel that no unnecessary strain may be imposed on the cable.

Anchor buoys, although very useful for marking the position of anchors, have fallen into disuse. This may be owing to the fact that vessels do not as a rule stay long at single anchor; also, there is the possibility in steamers of getting it foul of the propeller.

Effect of Long and Short Scopes of Cable.—The holding power of an anchor varies with the amount of cable out. The shorter the scope the more upwards is the pull of the ship on the anchor, and consequently the less hold it will have. *Vice versa,* the longer the scope the more horizontal is the pull, and the better the anchor will hold, the best position being attained when enough cable is out to ensure the pull being quite horizontal with some of the cable along the bottom. **One anchor with a sufficient scope for this purpose will hold better than two anchors with an insufficient scope**

A vessel anchored in deep water, with a proportionately long scope of cable out, will ride easier in a sea, than when in shallow water under the same circumstances, owing to the catenary* of the cable giving more elasticity.

Veering Cable.—When it becomes necessary to veer cable in order to give more scope, precautions should be taken for veering it slowly and gradually. To veer away until slack, and then hold on, allowing the vessel to tighten it suddenly, would be very likely to break the anchor adrift. With respect to dragging, the saying "**prevention is better than cure**" applies with special force. An extra length or two of cable, given in time, may ensure the anchor holding, whereas, if not given and the anchor starts, it may be impossible to get it to hold again.

A ship at anchor will be influenced by one or both of two forces, *i.e.* the tide acting on the immersed part of the hull, and the wind pressure on the exposed parts of the hull, and on the spars, rigging, etc. In a tideway the principal factor in the management of a vessel is the helm.

A "*weather tide*" is a tide setting to windward.

A "*lee tide*" is a tide setting to leeward.

Usually the effect of the tide on a vessel at anchor is greater than that of the wind, though in strong winds, or weak tides, the reverse may be the case, especially with vessels light or in ballast.

A vessel at anchor riding to the tide is moving through the water. If riding to a 3 or 4-knot tide the vessel has the same relative

* A catenary is the curve which a chain or rope assumes when suspended between two points. The curve of a tow-rope when a ship is towed, also, when a ship is at anchor, the curve of the cable between the hawsepipe and the point where it rests on the bottom are examples of catenaries.

motion through the water as if she was being towed at the rate of 3 or 4 knots in still water It is sometimes helpful to look at the subject in this light, and to regard the anchor as towing the ship through the water.

Effect of the tide.—The effect of the tide is least when the ship is stem on to it, and increases as she comes athwart, being greatest when broadside on. The strain on the cable is, therefore, least when the ship is stem on to the tide with the anchor right ahead To keep her thus, however, would necessitate steering her as if under way, and under ordinary circumstances where there is no likelihood of dragging, this is not necessary or convenient because if left to herself with the helm amidships she would yaw about; it is best to give her a sheer to one side of her anchor with the helm, so that with the helm and cable together the ship will be kept fairly steady.

When, however, the tide is strong and holding ground bad, and there is any risk of dragging the anchor, only very little sheer should be given, as the more sheer a vessel is given the greater is the tension put on the cable. Under these conditions, therefore, in order that the ship may be kept as steady as possible, it may be advisable to steer the ship as if under way.

When a vessel is sheered to one side of the anchor, and the tide coming on the wrong bow shoots her across to the other side of her anchor she is said to "break her sheer." It must be borne in mind that it is not a steady continuous strain which is most likely to start the anchor, but the easing up and sudden tightening, such as would occur if a vessel broke her sheer, or if she is rising and falling in a heavy swell or sea.

Wind and tide.—The effect of strong winds on a vessel at anchor may be considerable, especially if she is light. If the wind and tide are ahead the effect of the two will be combined, and if there is a risk of driving the precautions already stated should be taken.

When the wind and tide are in opposite directions the ship is affected by the difference of the forces, and by judicious management the strain upon the cable may be considerably reduced. Suppose the ship to be tide rode with the wind aft; the effect of the wind will be to ease the strain upon the cable. Imagine now that the wind increases until it has a greater effect than the tide; the ship then begins to forge ahead towards her anchor. She must be steered clear of the anchor until she is ahead of it, when the cable will bring her up again. Be careful to keep her head on to the tide by meeting her with the helm, as though the wind may be strong enough to drive her up against the tide when

stem on to it if she got athwart the tide it would, unless very weak, have more effect on her than the wind and drive her back again, probably fouling or starting her anchor

Tending ship when moored.—A vessel when moored does not occupy so much room as when at single anchor, also, she cannot under ordinary conditions foul either of her anchors She does not therefore require tending in the manner that a ship does when at single anchor There is, however, a great disadvantage in being moored should a strong breeze spring up across the line of mooring, as the ship will be riding to a span This is especially dangerous if the ship is moored taut It will be well to illustrate this with a diagram.

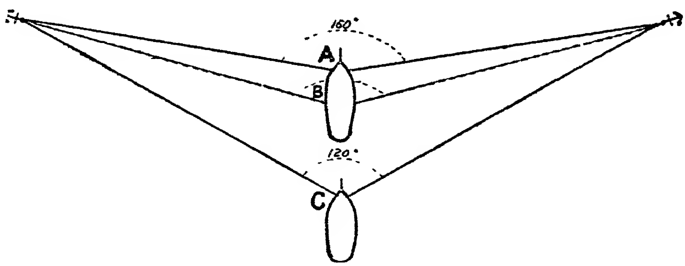


Fig 10.

A. Represents a ship riding to a span with *an angle of* 160° between the cables The tension or force on each cable is *three times as great* as would be put upon a single one ahead That is to say, an anchor and cable ahead would have three times as much holding power as the other two combined

B. Here the cables are supposed to be veered out so that the ship drops from *A* to *B*, with an angle of 150° between the cables The tension in this case on each one would be about *twice as great* as on a single one ahead

C. The angle here is 120°, in which case the tension on each cable would be just equal to that on one ahead.

Keeping a clear anchor.—The fact that the anchor when in use is out of sight frequently leads to its being ignored or neglected. Really, it should have the opposite effect, for if fouled it constitutes a hidden danger; and though the consequences may be no more serious than to cause the extra work necessary to clearing it when getting underway, it may render the anchor insecure or unsafe at the very time when it is most required.

The fundamental principle of keeping a clear anchor when swinging is to keep the vessel as far as possible from her anchor, or in other words, to keep the cable as taut as possible. The weight of the cable itself is considerable and must be taken into consideration. Under normal

conditions of wind and weather, it will, as the tide slackens, gradually sink to the bottom, and by its weight hold the ship's head to a certain extent; hence it is necessary to sheer the ship into a favourable position for swinging before the tide is spent.

It is generally recommended to swing the ship on the same side of her anchor at each turn of the tide if possible, in order to prevent drawing the chain round the anchor. It is not always possible to do this, as a shift of wind may render it impracticable. It does not follow that, if she swings on different sides, the chain will foul the anchor, as the anchor, under average conditions of wind and tide, would probably slew in the ground at each turn of the tide. These remarks on tending ship apply more to the old fashioned anchors rather than to the patent, self-stowing, stockless type.

ANCHOR WORK.

1. Which is the working anchor in the Northern hemisphere, and for what reason?

The port anchor. The reason is that if a vessel is riding to her port anchor, and is afterwards obliged to let go the second one, when the wind hauls and she swings round to it, the cables will lead clear of each other and there will be no chance of getting a foul anchor.

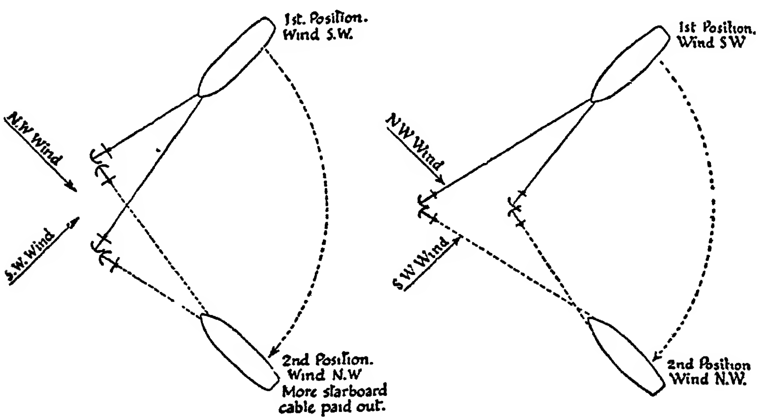


Fig. 11.

In the Northern hemisphere the wind hauls to the right, shifts of wind from S.W. to N.W. being common occurrence.

A vessel riding to her port anchor (wind S.W.) may find it necessary

on account of increasing wind to let go her starboard anchor, and to pay out on both cables. She will then have more cable out on her port anchor than she has on her starboard one. (First position in left hand diagram on p 314.)

When the wind hauls to the N.W. she should pay out more starboard chain, and will swing round with her cables all clear and the anchors in a good position each a little on their own bow. (Second position in left hand diagram on p. 314.)

If she were riding to her starboard anchor and then had to let go the port one, she would have less cable out on the port anchor than she had on the starboard one. (First position in right hand diagram on p. 314).

As the wind hauled and she swung round to it, she might drag her starboard cable foul of the port anchor. Even if she did not do so, the port anchor would be on the starboard bow, and the starboard anchor on the port bow with the cables crossing. (Second position in right hand diagram on p 314.)

2. Which anchor would you use when bringing up in the Southern hemisphere; and for what reason?

The starboard one. In the Southern hemisphere the wind hauls to the left, and if I brought up with my port anchor and later on had to let go the starboard one, I should have a cross in my cables when she swung round as the wind shifted. I might also drag my port cable foul of my starboard anchor.

To keep my cables clear, whatever I did with my port anchor in the Northern hemisphere I should do with my starboard anchor in the Southern hemisphere.

3. You are at anchor riding lee tide, what would you do if you found that she was dragging?

If I thought that she would hold by giving her more cable, I should do so at once. If not, I should give her a sheer and let go the second anchor, paying out on both cables.

4. You are lying at single anchor in a tideway. How would you prevent the cable fouling the anchor at slack water?

Give her a good sheer from her anchor just before slack water. This will draw the chain clear, and she will turn the anchor round in the ground as she swings to the new tide.

5. You are riding weather tide in a strong breeze, where will your anchor be lying?

If the wind has more effect on the ship than the tide has, she will forge ahead of her anchor and probably lie partly athwart the tide. The anchor will then be on the quarter and remain there as long as the wind is strong enough to keep the ship in that position.

If the wind moderates so that the tide has the greater effect, she will drop back again, and the anchor will lie ahead.

6. Where would the anchor be if you were riding lee tide?

Ahead, unless I gave her a small sheer from it, in which case it would be a little on the bow.

7. How would you heave your anchor up if your hawsepipe was badly damaged?

Hang a kedge anchor over the bow in a suitable position, lash it securely with chain, and let the cable come in over one of the arms.

8. You are riding to a strong tide with a shoal on your quarter; how would you sheer your vessel?

I would sheer her towards the shoal so that, in the event of the ship breaking her sheer and starting the anchor, she would go away from it. Also, the anchor, when the ship was sheered towards the shoal, would probably be pulling towards rising ground and hold better.

9. You are anchored astern of another vessel in a tidal river. What would you do if you found that she was dragging her anchor and driving towards you?

Veer away as long a scope as possible on the cable and try to get clear of her by giving my ship a broad sheer. Should screw the windlass up with a shackle just abaft it ready for slipping, if necessary. Buoy the cable. Have good fenders handy.

10. You have managed to clear her, but she has fouled your cable with her anchor. What would you do?

Slip it, and bring up with my other anchor. If I had steam I should have no difficulty in picking out another berth, or steaming away clear if the river was overcrowded with shipping. If no steam, should have to be specially careful not to get athwart of any other vessel or go ashore.

11. What would you do if the positions were reversed, and you were driving down towards another vessel?

Let go my second anchor. Use my engines if I had any steam. If

I continued to drag I might clear her by giving my ship a broad sheer. Should signal to her to sheer the opposite way if she was not already doing so.

12. What special precautions would you take if you were obliged to anchor in a river where the holding ground was known to be bad?

Should keep steam up, and if necessary, ease the strain on the cable by going slow ahead on the engines. Have proper watches kept so that I was ready to get under way at any time.

13. What would you consider your special duty as regards anchors, cables, etc., if you were mate of a ship?

Make myself thoroughly acquainted with the working of the windlass under all conditions. See that the pins were not rusted up in the shackles of the cables so that they could be quickly slipped, and that buoys with good buoy ropes were kept handy. Have my spare bower anchor stowed where it could be easily got over if necessary. Overhaul my stream chain and see that the shackles belonging to it were in good working order, and that it was stowed handy and ready for use.

14. What is the difference between riding to two anchors and being moored to two anchors?

A vessel is said to be riding to two anchors when they are both ahead of her, such as is the case when she has had to let go a second anchor to hold her in bad weather.

She is said to be moored when she has one anchor ahead and the other leading stern to hold her in one position.

15. What advantage is there in being moored to two anchors as compared with riding to one anchor?

The ship covers much less ground in swinging. By riding to the flood on one anchor, and the ebb on the other one, she turns round practically in her own length.

When riding to a single anchor she swings from flood to ebb or ebb to flood on the full length of her chain, and, except with stockless anchors, there is also the possibility of the chain getting under the stock and making a foul anchor unless carefully tended.

16. What is the disadvantage of being moored to two anchors?

The fact that should bad weather come on, my second anchor being down astern of me, it is of no use in helping to hold the ship.

17. You are moored in a roadstead, one anchor to hold her on the ebb tide and the other on the flood. A gale springs up from abeam so that she swings to it with the cables across the stem. What action would you take?

Slack away gently on both cables so as to bring the lead of the cables more ahead. Pay out with due regard to the depth of water I shall have astern at low water. When the gale dies away heave them both in again.

18. You are moored in a river riding to the starboard anchor. A gale springs up from ahead and the ship begins to drag. What would you do?

Pay out gently on the riding cable, heaving in the slack of the other. As long as the ship kept on dragging I should continue to pay out on the starboard cable. After passing the port anchor I should get a strain gradually on the port cable. The two anchors should then hold her.

19. Lying at single anchor, your ship is sheering about heavily. What would you do to steady her?

If there was any tide I should send a hand to the wheel to steer her. By tending her carefully the sheering could be prevented.

If no tide, she might be steadied by setting fore-and-aft sails with their sheets amidships. These would help to keep her on one side of her anchor.

If sails proved to be useless I should wait until she sheered the right way bringing the anchor well out on its own bow, then let go the other anchor and pay out cable on it.

20. You are lying at single anchor with a gale expected. What precautions would you take?

Heave in some of the cable to which I was riding, give the ship a sheer from her anchor, let go the second anchor and pay out on both cables.

21. You are in a vessel moored in a river. She sheers towards the bank on her port side. What would you do?

While the tide was strong enough she could be kept in position by a hand at the wheel to tend her if necessary. If I had steam I should make use of the engines.

22. How would you keep a clear hawse when your vessel is moored?

Just before the finish of every tide I should give her a cant with the helm so that the new tide will always swing her round on the same side of both her anchors, *i.e.*, on the same side of an imaginary straight line joining the two anchors.

When a vessel is properly moored where there is room to swing either way, a clear hawse can always be kept by canting her head to port before the turn of the tide when she is riding to her starboard anchor, and to starboard when she is riding to her port anchor.

23. You are moored near the bank in a tidal river. How would you tend her and keep a clear hawse?

When the tide is finishing give her a sheer with the helm, canting her stern out from the bank in the deeper water. The new tide will then catch her on the quarter and swing her round the right way. I should do this every time the tide changes. As long as she swings on the same side of both her anchors at every turn of the tide she will always keep a clear hawse.

ANCHORING, MOORING, Etc.

Use a small model when studying this subject.

24. How would you bring a steamer to anchor in an open roadstead at slack water?

Slacken speed as I approach the anchorage, and stop the engines when necessary. Have both my anchors ready, and see that everything is clear of the cables and windlass. If there is a strong wind, round her head up towards it. When in the berth I wish to take up, give her a little sternway with the engines, and let go the anchor.

25. How much cable would you give her?

That will depend on the depth of water, the weather conditions at the time, and the quality of the bottom. In fine weather and with good holding ground, five times the depth of water should be enough.

26. How would you bring up with two anchors in an open roadstead in bad weather?

Slacken speed, round her to, and before she comes head to wind let go my weather anchor and pay out cable. Sheer away from it, stop my engines, and when she has lost headway and begins to drop back let go the other anchor. Pay out plenty of cable on both anchors,

use my engines to ease the strain on the windlass when bringing her up.

27. You are proceeding up a river on the ebb tide; how would you come to an anchor?

Ease down the engines as I come to my berth, and stop them at the proper time. As soon as the tide begins to take her astern over the ground, let go the anchor

28 You are going up a river on the flood tide, how would you come to an anchor?.

Round her to and stem the tide. Ease her down and stop the engines. As soon as she begins to go astern over the ground let go the anchor.

29 You are coming up a river on the flood. How would you make fast to a mooring buoy with your cable?

Hang one anchor off, unshackle the cable and have it all ready in good time. Steam up past the buoy, round her to and stem the tide. Come ahead easy up to the buoy and put a good slip rope or wire on to it to hold her with. Reeve a 4-inch rope through the ring, bring the end back on board and make it fast to the cable about a couple of links from the end. Heave it out and shackle on.

If no shore assistance and I had to use my own boat should lower it into the water before I passed the buoy. They could then drop up to the buoy with the tide.

30. How would you moor her head and stern *between two buoys*, same flood tide?

Come up the river till above both the buoys, round her to and stem the tide. Steam slowly (against the tide) past the buoy for my stern moorings, and make well fast to the buoy ahead. Should shackle my cable on to it or use good wires.

Having finished forward, run a line out to the after buoy and get my stern moorings on to it. Make them well fast.

31. How would you moor her in between the same two buoys if you had arrived there with the ebb tide coming in?

Steam slowly up past the first buoy which I shall use for my stern moorings, use my engines as required and make her well fast to the buoy ahead. Get my stern moorings out afterwards.

32 You are coming up a river on the flood, how would you make an ordinary moor? You want 60 fathoms on the port anchor and 45 on the starboard one.

Round her to and stem the tide. Steam slowly up into the right position, stop the engines, and as soon as she goes astern over the ground let go the port anchor. Slack away freely at first, gradually checking her until I had 105 fathoms out, when the ship being held by the port anchor I should let go the starboard one. Pay out to 45 on the starboard anchor and heave in 45 on the port one. Should use the engines to ease the strain on the cable as I hove in.

33. How would you make a running moor under the same conditions?

Round her to and stem the tide. Work her into the right position and let go my port anchor while steaming slowly up against the tide. Stop the engines when necessary, slacking away on the cable until I had 105 fathoms out. The ship should then be stationary over the ground with the port anchor astern of her and the cable in a straight line along the bottom As soon as she begins to drop back with the tide, let go the starboard anchor, pay out gently to 45 fathoms, at the same time heaving in 45 on the port one.

34. How would you make a running moor with the tide finishing up with 60 fathoms on the port anchor and 45 on the starboard one?

Come up very slowly. Have no more than steerage way on my ship, stop my engines as I approach my berth, the tide will take her up over the ground. When in the right position let go the port anchor paying the cable out freely at first, but gradually checking her until I had 105 fathoms out and she had swung round slowly to port and was stemming the tide. I should then let go the starboard anchor and pay out to 45 fathoms, at the same time heaving in 45 on the port one. Ease the strain by going slow ahead on the engines as I hove in.

35. What would you do if the cable parted while you were making this running moor, the ship having got nearly athwart the tide at the time?

Heave in the slack chain that was left (if any) and straighten her up to stem the tide as soon as possible, taking care not to get foul of anything that might be about. I could then let go my other anchor and ride to that for the time being. Should get my spare bower shackled on to the remaining cable so that it was all ready for use until I was able to recover the other anchor.

36. What would happen if other vessels were anchored so near that you had not enough room to round her to before bringing up?

I should use my engines and steam away clear of them. Whether I went ahead or came full speed astern would depend on the positions of the other vessels, the depth of water, my distance from the river bank, etc.

If not able to do this, I should drop my starboard anchor immediately and **snub her round** with it. The cable would be across the stem until she swung round, but that could not be avoided in this special case of emergency. Should ease the strain on the cable by going ahead on the engines as soon as practicable.

37. Would you prefer to make a running moor with the tide or against the tide, and for what reason?

I should prefer to make it against the tide. The reason is that there is not so much risk involved by stemming the tide and steaming up against it, as there is by dropping the anchor while going with the tide and swinging her round to it. Too much strain may be brought on the cable and windlass by the latter method, even though the ship may have been going very slowly.

38. When mooring a ship, why do you sometimes give her more cable on one anchor than on the other?

Because in many places the tide runs stronger in one direction than it does in the other, and more cable is required on that anchor which will have to hold the ship against the stronger tide.

Prevailing winds blowing with the flood would make it necessary to give her more cable on the anchor holding her to the flood tide; if they blew with the ebb, she would want more on the anchor holding her when riding to the ebb.

SENIOR OFFICER'S WORK.

ACCIDENTS.

The internal organisation and appliances on board ship are designed to enable the routine work to be carried out smoothly and without accident, but "to err is human" and materials may fail at a critical period. It is the duty of responsible officers to anticipate sudden emergency calls and to think out in advance what should be done in the event of various contingencies arising. Circumstances alter cases

and accidents come unexpectedly; they catch us unawares and not always under the ideal conditions of an examination room.

The following hypothetical questions and answers may offer guidance and inspiration

1. Your steering gear carries away. What would you do?

Stop the engines Steady the rudder by bringing the brake into action on the quadrant. Put up the "not under command" signal. Repair the damage.

If one of the chains had parted, say the starboard one, the rudder could be put hard to port to haul the port chain tight, the rudder would, of course, have to be clamped in that position by the brake. The strain on the chain would then assist the brake in keeping the rudder quiet whilst the repairs were in progress. When finished, unclamp the brake off the quadrant, go ahead on the engines and take down the "not under command" signal.

I could connect up my hand steering gear and use that temporarily.

Most ships are also fitted with heavy steering tackles and suitable leads for them to be used in case of emergency.

2. Your steamer in heavy weather takes a big sea over the forecastle-head which damages No. 1 hatch. What would you do?

Ease her down. If necessary heave her to. Repair the damage. Inform the engineers before heaving to so that they may ease the steam pressure accordingly.

3. How would you heave her to?

By bringing her head slowly in to the direction in which you find she lies easiest and makes the best weather of it. That would probably be with the sea a little on either bow. Keep the engines turning just fast enough to maintain her head in that direction. Fore-and-aft sails may be useful for steadying purposes.

4. How would you heave her to if you were running before a heavy sea?

Have everything well secured about the deck and see that the crew are clear out of the way. Ease the engines down. Watch for a smooth and at the first good chance put rudder to port and let her come to gently. Spread oil freely from the weather bow as she comes up towards the wind.

In the case of heaving to in a gale of wind and heavy sea it is not only the weather conditions which have to be considered. Much

must depend on the ship herself and the state of her trim. Some ships lie very well *when they are kept before the sea* with their engines going slowly ahead.

5. You are running before a heavy gale and the ship is labouring badly. What could you do to relieve her?

Reduce the speed to that at which she makes the best weather of it, having regard to the fact that the faster I can keep her going the less likely she is to take heavy seas over the stern Spread oil judiciously. I might alter the course so that she will take the sea more kindly.

6. When heaving to in a steamer would you prefer to carry the wind on the port side or the starboard side? State the reason.

I should prefer to carry the wind on the port side. With engines going ahead and the ship having a right handed propeller, the tendency of the side thrust is to cant her head to port. She would therefore lie up better with the wind on the port bow than she would with it on the other side.

7. What makes a vessel roll?

The waves or the swell. The magnitude of the rolling depends upon the state of the vessel's stability as well as on the amount of sea which is running. A "stiff" ship will roll more violently than a "tender" one.

8. Your ship is rolling heavily. What can you do to steady her?

An alteration of course would be the alternative. I should keep her going in the direction (as near to my proper course as possible) in which she made the best weather of it. Should steam at a reduced speed if I did not like the track she was making. Should heave to if necessary.

It would be very dangerous to do anything in the way of emptying or filling ballast tanks while the ship was rolling heavily. The rush of water in a partly filled tank might damage the crown of the tank which would then let water into the hold. If the tank was being "run up" the result might be very serious before the damage was discovered.

9. Your funnel goes over the side. What would happen and what would you do?

The decks would be enveloped in smoke, heat and clinkers would be troublesome, and the draught through the furnaces would be very much reduced.

I should rig up a jury funnel. Possibly the engineers could make a cylinder from some spare ventilators and other stores on hand. This could be erected on the funnel coamings. If not long enough, a wooden shaft lined with sheet metal and covered with canvas could be added to it. Plenty of guys would be required to steady it. The hose should be played on it frequently to prevent it being quickly scorched through. This would increase the draught and carry the smoke up clear of the deck. It would want a lot of attention and probably would not last very long.

10. You have a strong wind on the starboard quarter. A man falls overboard. What would you do?

Heave him a life-buoy. Stop the engines. Rudder hard over to the side he fell off; start engines again and steam right round to windward of the man under easy revolutions Have the emergency boat cleared away and manned with a suitable crew. When in a good position heave to and lower away the boat, spreading oil for a smooth. While they are picking the man up, manoeuvre the ship into position to make a lee for the boat, again spreading oil before she comes alongside. See that the boatrope is ready with hands to tend it. Hook on and hoist her up as quickly as possible

11. Your vessel has taken the ground at low water and her bottom in the way of No. 1 hold has been pierced by the anchor. What would you do

When the tide makes again she will float on her tank tops. Take her into dry dock. Call a survey. Have the damage repaired. Get certificate of seaworthiness.

If no dry dock or patent slip is available I should take safety precautions by stiffening my tank tops, carrying out surveyor's requirements. Should then obtain permission to proceed to the nearest port where permanent repairs could be done. This would be granted by the surveyor when he was satisfied that the ship was seaworthy. Get certificate of seaworthiness in duplicate. Send one copy to my owners.

12. You are passing to windward of a sandbank in a strong wind. The tide is setting on to the bank. Your engines break down. What would you do?

Get to windward all I can while I have any way left over the ground. Bring up at once using both anchors if necessary. Give her plenty of cable on both of them. Get the damage repaired as soon as possible.

13. You are coming up a narrow river on the flood tide. How would you turn her round?

Stop the engines in good time and sheer her gently in towards the bank on my starboard side. When far enough ahead come full astern on the engines and drop the starboard anchor under foot. Her stern will swing round up river with the tide. Lift the anchor, rudder to starboard, go ahead on the engines. Straighten her up.

14. Suppose you were in the North Sea and your rudder got disabled. What would you do?

Come to an anchor. Use my best resources to repair the damage. If impossible to get the rudder working properly I should try to steer her by towing something astern and running the towrope across from quarter to quarter. This could be done by means of a gin running along a wire stretched round the stern for that purpose. This might enable me to reach port. Should send a wireless message in code to my owners, explaining the circumstances fully and giving the position of the ship. Assistance could then be sent if required.

If my ship had twin screws I could run one at a regular speed (not full speed) and steer the ship by increasing or decreasing the revolutions on the other.

15. Your rudder plate is damaged. You are in dry dock. How would you unship the rudder for repairs?

I should unship only the lower part. It would not be necessary to disturb the quadrant or rudder head.

Rig two good three-fold purchases over the counter, one on each side. These can be suspended from the after bitts.

Put the helm hard over, it does not matter which way.

Secure the lower purchase blocks to the upper part of the rudder plate by means of shackles, or lash them with a good chain lashing round the rudder spindle underneath the flanges of the coupling.

Take a strain on both purchases and make them fast.

Disconnect the rudder coupling by taking the bolts out of the flanges. Then put the helm hard over the other way so that the two flanges become clear of each other, and the lower part of the rudder can be lifted up.

Disconnect the locking pintle.

Have a screw or hydraulic jack in the dry dock underneath the bottom of the rudder. Raise the rudder with jack, heaving away on

the purchases at the same time until the pintles are clear of the gudgeons. Remove the jack. Guy the bottom of the rudder clear and lower away.

16. How would you manage if you had to do the same job with the ship afloat?

Rig the two three-fold purchases and secure them to the rudder in the manner just described. Disconnect the rudder coupling and locking pintle.

Raise the quadrant and rudder stock high enough to get the lower part of the rudder clear. This could be done with a jack on deck underneath the quadrant or by means of wedges between deck and quadrant.

Heave away on both tackles until the pintles are clear of the gudgeons. The rudder will then be free of the rudder post.

Slack away on one tackle until the rudder is hanging by the other. Heave it up and land it on a barge. If alongside a wharf or in dock I could dispense with the barge by getting a crane on to the rudder and lifting it ashore direct from my tackle.

17. How would you unship an old-fashioned rudder? The spindle and stock are in one piece.

When dry docking the ship inform the dockmaster that I want her settled down on the blocks with her rudder over the rudder pit in the bottom of the dock. This to enable me to lower the rudder down far enough to get the head out of the rudder trunk.

Clear away the rudder head by removing the key and taking off the crosshead and quadrant. Clear out the stuffing box. Remove the collar plate from around the bottom of the rudder trunk, also the locking plate from the rudder. Tap a hole 1 inch in diameter vertically in the rudder head. Screw into it a stout eye-bolt for lifting purposes. Rig a pair of short stout sheerlegs over the rudder head, seeing that the deck is shored up underneath them. Hang a good threefold purchase from them. Use iron blocks and a wire fall. The lower block must be small enough to go down through the rudder trunk. Shackle it on to the eye-bolt which you have screwed into the rudder head. Take the weight of the rudder in the purchase, a jack under the bottom of the rudder will help to lift it enough to get the pintles out clear of the gudgeons. Make the fall of the tackle well fast and remove the jack. Open up the pit in the dry dock underneath the rudder post and lower the rudder down into it. Remove with another tackle or the dock crane.

If I had to unship the rudder while the vessel was afloat the procedure would be the same except for two things. I should not be able to have a jack underneath the rudder to assist my purchase when heaving up; also, when the rudder head was lowered down clear of the trunk I should have to get another purchase on to it to lift the rudder up into a barge, or possibly on to the dock wall if alongside.

18. How would you unship a propeller?

With two tackles hung over the quarter, one on each side. They should be three-fold purchases, and either wire or manila may be used for the falls. Sling the propeller round the boss with good chain, and shackle the lower blocks of both purchases on to it. Take the weight, putting an equal strain on both tackles. Unscrew the lock nut. Remove the key. Start the propeller by means of steel wedges. In some yards hydraulic power is used. Disconnect an intermediate length of shafting. Draw in the tail shaft. Slack away on one tackle. The propeller will then swing out clear of the stern frame, the whole of the weight gradually coming on to the other tackle. Land it on some heavy planks or on to a trolley if it is to be moved away.

19 Your windlass is broken down. How would you heave up your anchor?

With a tackle. Reeve off a good three-fold purchase. Take the block having the hauling and standing part of the rope in it and shackle it on to the cable close abaft the hawsepipe. Overhaul the purchase to a good long drift and make as fair and clear a lead as possible. Attach the other block to some secure object such as a pair of bitts or a side bunker hatch. Do all that can be done to avoid chafe.

Take the fall to a fore deck winch and heave away. Use the engines to ease the strain on the purchase. It will be necessary to stopper the cable off and fleet the purchase from time to time. Heave the anchor right up into the pipe and secure it.

If unable to get the anchor away by this means, make the cable well fast and break the anchor out by going ahead on the engines.

20. Your kedge anchor is foul. How would you recover it?

Get two motor boats away and sweep for it with a bight of wire. Having got the anchor in the bight, bring the two parts of the wire together, place a large shackle round them and let it run down on to the anchor. Heave away on both parts of the wire.

21. One of your bower anchors is damaged. How could you replace it with the spare one?

Lower the damaged one down until it is just clear of the hawse pipe. If no crane on the forecastle-head I should use No. 1 derrick and winch for handling it. Overhaul the wire along outside clear of everything and shackle it on to the ring Have steam on the windlass. Heave away on the wire (see the derrick is properly guyed) and walk back the windlass. Light up the weight of the cable if necessary. Get the anchor in on the foredeck or forecastle-head. Put a lashing on the cable to prevent the end running away. Unshackle it from the damaged anchor and put it on to the spare bower. Shift your derrick wire on to the spare bower. Come up the clamps and lashings securing it on its bed. Don't forget the lashing on the cable.

Take the weight on the derrick and guy it out to the side as required. Come back gently on the winch and heave the cable slowly in with the windlass until the anchor is under the hawsepipe. Unshackle the derrick wire, heave the anchor up into the pipe and secure it.

If the combined weight of the anchor and cable is too much for the wire, I should hang a block at the derrick head and reeve off a purchase which would be suitable for the job. A wire pendant might come in useful if the drift was a long one; or:—

Lift the damaged anchor on to the deck without the cable. Hang the anchor off under the hawsepipe and unshackle the cable. Reeve a good wire out through the hawsepipe to take the place of the cable. Lead it to a winch. Take the weight of the anchor on your derrick and hawsepipe wires. Cast adrift the lashing with which you hung off the anchor. Slack away your hawsepipe wire and heave the anchor up on to the deck with the derrick wire.

Get the spare bower down under the hawsepipe with the same two wires. Shackle the cable on. Get the wires adrift from the anchor. Heave it up into the pipe and secure it.

22. You come across a steamer which has lost her rudder. How would you assist her into port?

Manoeuvre into a position astern of her. Take two good wire hawsers, one from each of her quarters, and make them securely fast on my forecastle-head. Shackle them on to my cables if I expected bad weather so that there shall be some spring in them.

Let her go ahead of me, making the best speed she can under the

circumstances, when I should steer her by following astern and keeping a little strain on the wires.

23. Your engines have broken down in heavy weather. What would you do?

Keep the ship out of the trough of the sea as much as possible while the engine-room staff get on with the repairs. If the water is not too deep, unshackle the cable from one or both of the anchors, pay out a long scope and let it drag along the bottom. Fore-and-aft sail might also help to steady her. Spread oil to windward. If the water was too deep for the cables to keep her head up, should do the best I could with a sea anchor. Hoist the "Not under command" signal.

24. Your ship has a right-handed propeller. How would you turn her short round with her head to port?

Let go the port anchor under foot. Go slow ahead on the engines with the rudder to port. When turned sufficiently heave the anchor up again and proceed.

25. You are bound to the Bristol Channel in ballast from the Continent. Heavy westerly gales are blowing. How would you make westing down towards Land's End?

Proceed down Channel with the ebb tide, and if possible anchor against the flood. Take every possible advantage of changes in wind and weather. Get in a good position to bring up each time the tide turned against me. If I could not do any good against it, should run in for shelter. The Downs, under the lee of the Isle of Wight, Weymouth Bay, Portland Roads, Tor Bay, Falmouth and Mount Bay all offer good shelter in westerly gales.

26. You are anchored ahead of some vessels riding to the flood tide. Port anchor down. No steam on the main engines. How would you get her up the river and enter a dock on your starboard hand?

I should dredge her up the river with the tide, passing in between the river bank and the vessels astern. Heave in cable until the anchor is nearly under foot and she will drag it along over the bottom. Wheel to starboard to shear ship to starboard clear of the vessels astern and dredge laterally and stern first up the river. When far enough across to clear the vessels at anchor, straighten her up by easing the helm and dredge her stern first up the river, closing in towards the dock

entrance. Ease her alongside the up river knuckle. Make her well fast and heave the anchor home.

Run a line from the starboard quarter well ahead on to the knuckle, also one from the starboard bow to be used as a check rope when required. This would be carried along the entrance to the lock by the pierhead men. Spring the vessel ahead with the quarter rope until she is half way past the knuckle and then apply the bow check and swing her head round into the dock entrance.

If there was any flood tide left I could help to get her round the knuckle by running a line from my port quarter on to the down river knuckle and taking it to the winch.

27. You are coming up a river on the flood tide Turn short round, making use of the tide.

If the river is fairly straight, the strongest part of the stream is generally in mid-river That being the case I should slow down, sheer in towards the bank on my starboard side to bring my bow into the slacker water, and when far enough in come full speed astern with helm amidships. The strong flood in mid-river will catch her on the starboard quarter and swing her stern round up river, when far enough, rudder to starboard and full speed ahead to straighten her up. Repeat if necessary.

HOW TO RIG A SEA ANCHOR AND USE IT FOR KEEPING A VESSEL OUT OF THE TROUGH OF THE SEA, Etc.

The best practical sea anchor for use in moderate depths of water is made by unshackling one of the bower anchors and paying out a good length of the cable only. This will drag along the bottom and keep the ship's head up towards the wind and prevent her lying in the trough of the sea. It is easy to rig as it only necessitates the hanging off of one anchor, and it is more efficient than any floating object could be.

For use in deep water, a sea anchor could be made as follows:—

Get a spar such as a wooden derrick or good boat spar, and lash the luff of a staysail or trysail along it. Secure a piece of chain or other weight at the clew. This weight must be heavy enough to make the sail hang vertically underneath the spar in the water but not so heavy that it will sink the spar. Rig a bridle with a good piece of rope attached to each end of the spar, and make the end of a hawser fast to the middle

of the bridle. Put it out over the bow and pay out a good drift on the hawser.

Three spars lashed together in the form of an equilateral triangle and covered with stout canvas would also answer the purpose. In this case a three-legged bridle would have to be used and one corner weighted as before.

Two spars lashed together in the form of a cross with a chain stretched from arm to arm to form the outline would also do, but would require a double bridle (four-legged); this would also have to be covered with canvas and weighted at one corner to keep it vertical in the water.

The two last mentioned have the disadvantage of being heavy, troublesome to make, and very awkward to handle.

A few large cargo baskets paid out on a long line would be easy to rig and might prove good enough.

Any floating object that will offer reasonable resistance to the drift of the ship will make a more or less efficient sea anchor.

An oil bag hauled out to the sea anchor by means of a block and small line would be beneficial in very bad weather.

Heaving a Vessel off When Aground.

1. What would you do if your vessel ran aground, no tugs or shore assistance being available?

Sound the wells, and if she was not leaking do my best to get her off again at the next high water.

If she was badly holed I should make sure that it was safe to get her off into deep water before attempting to do so. If possible, I should try to make a temporary stoppage of leaks before floating her, and in the meantime run my spare bower and another bower anchor out ahead, or take some other action to prevent her slipping off before I was ready. Should also make quite sure that my pumps were able to deal with any leakage that might remain or be likely to develop.

2. If you decided to get her off, how would you do it?

Take careful soundings to find out where the best water was, and try to get her off at the next high water by using my engines and ballast tanks to the best advantage. If practicable, shifting cargo might help me. Should consider the possibility of discharging some cargo to lighten her forward, but should not jettison cargo unless it became a matter of extreme urgency.

3. Suppose you could not get her off by this means, what would happen?

I should carry out my spare bower anchor, also one of my other bower anchors if necessary, and try to heave her off with them, of course, also using my engines and ballast tanks.

4. Are you running any particular risk by using your engines in this case?

There is the possibility in the shallow water of mud or sand or weed being drawn into the condenser tubes and thus temporarily disabling the engines. If I had two inlet pipes leading to the condenser should use the upper one as being less likely to get choked. Should also protect the inlet valve with a wire guard or some other arrangement if possible.

5. How would you carry a bower anchor out?

Between two boats. Lay a kedge and guess warp out in a position suitable for heaving out the boats carrying the bower anchor.

Shackle a good wire on to the spare bower, and lower it over the side with one of the forward derricks until the shackle is 3 feet or so above the water level. Bring the two boats along one on each side of it. Make a good spar well fast across the four gunwales about the middle of their length. Lash the shackle of the anchor to the spar making sure that the wire will be *underneath* the spar when the anchor is dropped. Ease the weight gradually from the derrick on to the spar and unhook or unshackle the anchor from the derrick.

Heave the boats out with the guess warp, paying the wire out from on board the ship. When in the right position cut the lashing and let go the anchor. Heave the boats back with a line also paid out from the ship as the boats went away. If the kedge was not required any more, pick it up and bring it back with me.

6. If the anchor was an old-fashioned one with a stock, would you carry it out in the same way?

Yes. I should, however, have the boats far enough apart to give clearance to the stock or be careful to hang the anchor low enough for the stock to be below the keels of the boats on account of possible damage if it swung round.

7. How would you manage if there was not enough water near the ship for you to hang it vertically?

Hang it horizontally between two spars. I should sling it carefully with the arms vertical and stock in a horizontal position, and lower it down to a suitable level, first shackling the wire hawser on to it Bring the boats along, one on each side of it, and lash two spars across the four gunwales, one to take each end of the anchor. Secure the upper fluke to one of the spars by means of a rope that could be gently eased away, and lash the ring to the other one. Heave the boats out with the guess warp as before. When in the right position, cockbill the anchor, that is, allow it to hang vertically by slacking away and then letting go the fluke lashing. Let go the anchor by cutting the ring lashing. See that the wire is all clear before letting go.

JURY STEERING GEAR.

In the event of the steam steering gear breaking down, the hand or emergency gear must be connected up, but should both carry away

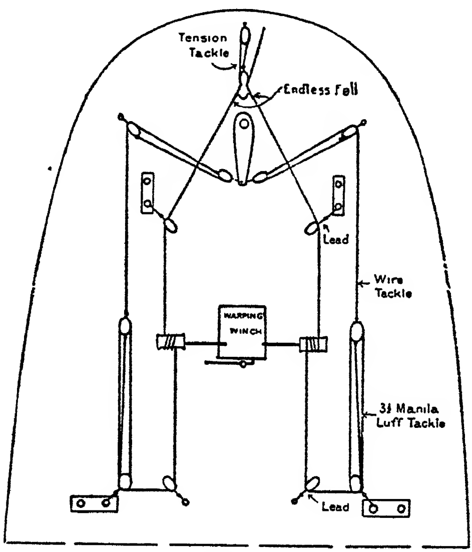


Fig. 12.

then ways and means of rigging a working attachment to the quadrant or tiller must be devised. The following efficient system of block and tackle gear was rigged up in the American steamer *West Harshaw*

while on a voyage from Galveston to Liverpool when the worm steering gear frame broke down in heavy weather, totally disabling both steam and hand gear. Wire tackles were attached to the tiller. Manila luff tackles were secured to the wire and led to the winch, turns being taken in opposite directions around the drumheads. Lead blocks were secured abaft each, with the ends of the luff tackle falls rove through them and bent together, making an endless purchase as shown in Figure 12. The tension tackle was used to take up the slack. The ship was steered in this manner to her destination a distance of 2000 miles, and this jury steering gear proved efficient.

JURY RUDDER.

When the rudder carries away at sea it will bang from side to side with the motion of the sea, unless it is possible to secure it hard over to one side or the other, and very probably the gudgeons and rudder post may be damaged, but even after getting rid of it considerable ingenuity will need to be exercised in devising and rigging up a jury rudder from the material on board capable of steering the ship. Much will depend upon the state of the weather, the size of the vessel, her draught and the practicability of working under her counter at sea. It would be a pretty hopeless task trying to rig up a working apparatus to steer a ship with a cruiser stern, but with an elliptical stern and the ship not too deeply laden an efficient jury rudder can be fitted at sea by the exercise of patience and perseverance as proved by the successful effort of Captain D. Forrest in the ss. *Braddovey* when her rudder was lost in the North Atlantic. The figure and explanation are from the *Dolphin and Guild Gazette* of January, 1929, by kind permission of The Imperial Merchant Service Guild, and will give an idea of the job when finished, but not of the strenuous and anxious time put in by those on board during the dangerous and tedious operation.

EXPLANATION OF PLANS, Etc.

The wire used was $2\frac{1}{2}$ inch flexible steel, and by using thimbles in the eyes and movable fairleads and blocks no chafe or wear was encountered. The derrick used was a 43ft. steel cargo derrick, the spider-band at the head being used for the topping lift and steering wires. The goose-neck being fitted into the gudgeon on the stern post, packed with a brass bush and secured by using a washer and two collars each with two $\frac{5}{8}$ inch

screw locking bolts. Again no chafe or wear was encountered and the gudgeon remained undamaged. The two 5 ft. by 3 ft. iron doors were fitted on each side of the derrick 4 ft. from the spider-band (to clear topping lift) and bolted with twelve $\frac{7}{8}$ inch bolts, six on either side of the derrick. Between the doors the space was packed with wood to make

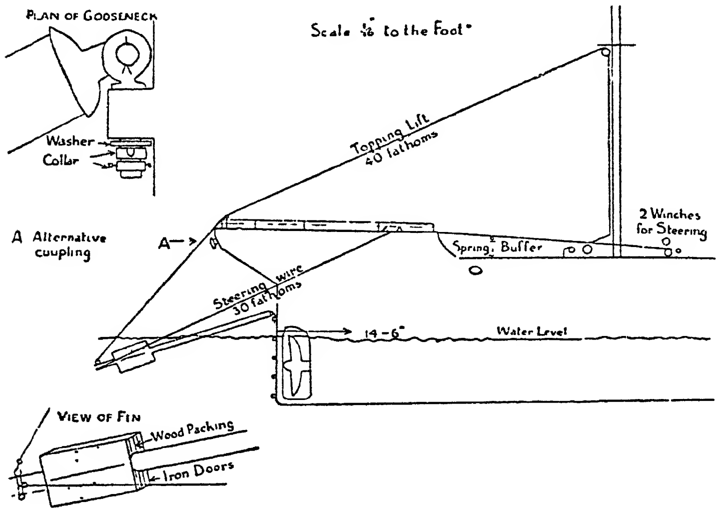


Fig 13.

the whole firm and solid, and the edges of the doors were again bolted. The long leads for the steering wires were used to allow any jerks to be taken up and a spring buffer was also used for this purpose. Length of derrick, 43 ft. × 10 in. (diam.); dimension of doors, 5 ft. × 3 ft.; height of goose-neck above water line, 5 ft.; wires and topping-lift, $2\frac{1}{2}$ ins. (steel mooring wire).

TOWING A DISABLED VESSEL.

Towing.—It is hardly necessary to touch upon the towing of vessels by tugs in smooth water. It will be more to the purpose here to consider the best arrangement for towing in bad weather, or in the case of a steamer falling in with a disabled vessel and agreeing to take her in tow.

Most modern vessels are now provided with steel wire towlines, of size proportionate to the size of the vessel, and with a coir or manila spring of equivalent strength for use in connection with the wire hawser

to afford the necessary elasticity which is lacking in the wire. Under ordinary conditions of wind and weather this is safe enough, but for bad weather a better arrangement is obtained by shackling the steel towline to the cable of the vessel to be towed, and veering out a good long scope, after which the cable is secured aboard in the same manner as if the vessel was at anchor. The weight of the cable will cause it to form a catenary, which will prevent sudden jerks.

It must be noted that the length of the towline is a most important point. The longer it is the more uniform will be the tension during the time of towing, the aim being as far as possible to secure a steady strain and to avoid slackening and consequent sudden tightening. Therefore no hesitation should be made when using the cable in paying out plenty of scope.

Where a disabled vessel is being taken in tow by a steamer there may be some difficulty in devising a safe arrangement for making the towline fast to the towing steamer, as the bollards or bitts in the after-part of a vessel are not usually fitted with the view of towing other vessels in bad weather.

A steamer picked up a disabled steamship in the North Atlantic and established towing connection as follows. The disabled ship unshackled a cable from her anchor which had a stock and was secured on forecastle-head. A boat was got ready for lowering to run out a small line across to the rescue; heavier lines and wires were also in readiness.

The rescue hove up cable out of the locker, knocked out the 15-fathom shackle and continued heaving out cable, dragged the end aft along the fore well deck, over the bridge deck, right aft to the poop and passed the end through the after leads in readiness for shackling on to the end of the other vessel's cable when it was hove up to the stern.

Everything being in readiness on board both ships the steamer was manoeuvred as close as possible on the lee bow of the disabled ship, but ready to instantly go ahead should they get too close, both vessels being about beam on to wind and sea. The boat was lowered, the small line run across and passed on board, the rescue heaving in and the disabled vessel bending on heavier lines and then a heavy wire. The end of this wire was lashed to her cable a few links up, leaving the end and shackle free.

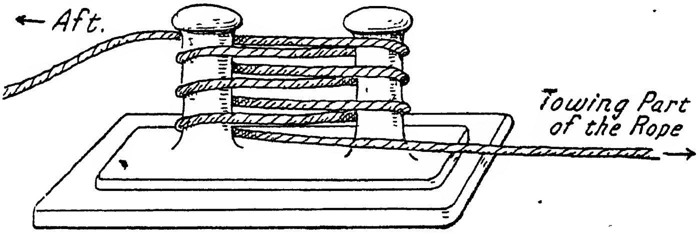
The cable was hove close up to the stern of the rescue and as quickly as possible the cables of the two ships were shackled together and towing

commenced, the disabled vessel paying out cable as desired. The cable of the towing vessel was led between the bollards aft and lashed to the other bollards along the deck to the windlass. It lay quiet and easy and did not surge under the strain. The tow was comfortably performed in Atlantic weather.

A great advantage is gained when towing in a seaway if the towing steamer distributes oil, which will make a smooth for the towed vessel.

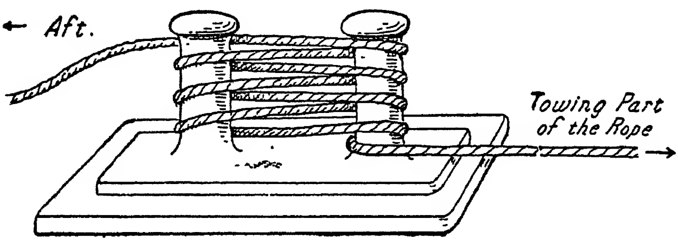
When the weather is such as to make it dangerous for the two vessels to come near each other, communication may be established by means of the line-throwing gun.

How to Make a Towrope Fast for an Ordinary Tow



The Wrong Way to Make the Towrope Fast.

Fig. 14.



A Better & Safer Way of Making the Towrope Fast.

Fig. 15.

Fig. 14 represents how a towrope should *not* be made fast. By this method the greater strain comes on the after bitt, which might be the cause of the bitts lifting aft and being torn out.

Fig. 15 shows a safer way. Here the greater strain is taken by the forward bitt, and though the after bitt has some they should hold the ship under ordinary conditions. If the rope is backed to another pair, further aft, greater security is obtained.

Dry Docking.--The dockmaster must be furnished with particulars as to the work to be done on the ship's bottom when in dock, and the repairs, if any, which are to be executed. He should also be made acquainted with the vessel's draught, whether she has bilge keels, and any other special characteristics of the ship's build which may be necessary as a guide to him in making preparations for receiving the ship in dock and in the fixing of the keel blocks. Special precautions will be necessary where a vessel has received damage to her hull through having been stranded or been in collision.

If possible, the ship should be a few inches by the stern and should be quite upright Slack water is the time for entering, and after arrival at the entrance the vessel is under the charge of the dock company.

If being docked for the purpose of cleaning and recoating the bottom, some responsible person on behalf of the ship should see that the work is done efficiently, especially so when work is being done after dark. Anti-corrosive paint or anti-fouling composition should not be put on a wet or damp surface if it can possibly be avoided. A careful examination of the ship's bottom should be made, and the engineers should examine the stern tube, propeller, injection valves, and sea connections, also if any part of the plating is found to be corroded or pitted it must be thoroughly cleaned and covered with some anti-corrosive coating. See also page 614.

Lloyd's recommend the dry docking of ships as soon after launching as may be possible, for the purpose of cleaning and recoating the bottom.

To Construct a Raft.—Take the three stoutest spars available and lash them together in the shape of a triangle. Strengthen the corners by lashing short stout spars across them, 2 or 3 feet inside the cross lashings. Inside each corner lash empty barrels or tanks if obtainable. The raft must then be decked over with good stout spars and planks, lashing or otherwise securing them to the framework formed by the triangle. Erect a spar for a mast, with stays to each corner to support it, have the heel well secured, and fit a suitable sail to it. Round about the mast lash barrels of fresh water, and store the provisions in tanks if possible. Life lines should be run round the raft from corner to corner.

Rescuing the Crew of a Disabled Vessel in Heavy Weather.—If in a steamship, get to windward of the distressed vessel, as near as is safe, and lie to with the wind and sea two or three points on the weather bow. Get the lee life-boat ready for lowering and call for volunteers. Man the boat before lowering, and let each man have a life-belt on. Before lowering, pass a good long line for a painter right forward to the bow

of the steamer; also pass a line round each boat fall to frap them in, and thus prevent the boat swinging out and coming back violently against the vessel when being lowered.* See that the boat is well supplied with oil, and bags for distributing it; also one or two spare life-belts. Before lowering the boat smooth the surface of the sea with oil, and then lower the boat into the water, and get clear of the vessel as quickly as possible. The steamer should remain in position to afford a lee shelter to the boat when going to the wreck.

The boat on approaching the vessel should be careful to look out for any floating wreckage. The people on the distressed vessel should be hauled into the boat by lines, with life-belts on. Oil should be used, both from the distressed vessel and from the boat.

In the meantime the steamer should have gone to leeward in readiness for the return of the boat. When the boat returns, if unable to come near enough to get the people aboard, the rescued people should be hauled aboard by a whip from a yardarm, or from a derrick well guyed out, oil again being plentifully distributed.

If the rescuing vessel is a sailing ship, it may not be possible to get to windward. In this case, if a rescue is to be attempted, lie to to leeward and distribute a good coating of oil. The distressed vessel and the rescuing vessel will be drifting to leeward, and the oil will make a smooth wake to windward for the boat and make it much easier to get to the distressed vessel.

THE SHIP'S LOG BOOK

1. For what purpose is a ship's log book kept?

To record the ship's progress so that her position by dead reckoning may be found at any time, and it is an important book of reference with respect to anything that occurs on board. Also in case of damage to cargo—entries in the log book showing how the damage arose would be valuable evidence.

2 Would you keep it in civil or astronomical time?

In civil time; that is, each day on one page, commencing at midnight and terminating the following midnight.

3. What are the usual daily entries to be made when at sea?

The courses steered, and distance by the log for each hour. Direction and force of the wind. Leeway (if any), also variation and deviation

* Choose the most favourable opportunity for lowering, when the vessel is as steady as possible.

of the compass. Any allowance made for the set and drift of the current. The ship's position at noon by observation if possible; also position by dead reckoning worked from position at previous noon; also position at any other times if sights are taken. Times during which the Regulation lights are exhibited Names of men on the lookout. Soundings of pump wells. Barometer and thermometer readings. Work done about the ship. Sail set or taken in, etc.

In a steamer I would also note any orders given through the telegraph to the engineers, distances on the patent log, and all other items of importance.

4 What entries would you make in heavy weather?

The kind of sea that was running, that is, whether a cross sea or a very high sea, etc , also how the vessel was behaving and whether shipping heavy seas, etc.; what sail was set; also I would note if she was labouring heavily, or if there was any evidence of straining in any part of the vessel, and if anything was carried or washed away. In a steamer I would note how the engines were going, if the propeller was racing much, hatches inspected, etc.

5. Why is it important to have entries of bad weather in the log book?

So that in case the cargo gets damaged through stress of weather, the log book may be produced in evidence thereof.

6. What entries would you make after anchoring in a river or harbour?

Depth of water, anchor let go, amount of cable out, direction of wind and tide, the state of the weather, barometer reading, and the bearing of some fixed objects ashore.

7. What entries would you make after taking soundings?

The time, depth of water, nature of ground; also distance on the patent log, and the estimated position of ship.

8. What entries would you make going along a coast?

The time of passing the principal points, and distance off them when abeam; also ship's position by cross bearings, sextant angles, or any other means when opportunity for doing so arises.

9. What entries would you make if you experienced foggy or thick weather?

The time it came on and at which fog signals were started, speed of

vessel, sails set (if sailing vessel), and how engines were going (if in a steamer). Any orders *re* engines, and times they were given.

10. Would you make any entries in port?

Yes; I would put down the hours during which discharging or loading was carried on, and amount put out or taken in, if possible, also the draft both aft and forward. If any delay was caused by rain, etc., I would make an entry of it, or any other item relating to the cargo which was worthy of notice. Also work performed on board; or if she was dry-docked, I would particularise as to what was done. Also if any repairs were made I would note them.

11. Where does the mate get the necessary particulars from for entering in the log book?

From the deck or rough log which must be filled in by each officer at the termination of his watch.

12. State any other important points regarding the log book.

If any damage to, or loss of, cargo arises during the voyage, a full account of the cause thereof, and the consequent measures adopted for its protection, must be entered in the log book.

The draught of water should always be entered on leaving port.

No erasion should ever be made, and great care should be taken to avoid having to make any alteration. If any alteration is necessary, it should be made by ruling a line through the part required to be altered—but not so as to render it illegible—and the correction should be then made and must be initialed and dated.

CHAPTER XIV.

MENSURATION.

WEIGHTS AND MEASURES.

Troy Weight.

24 grains	=	1 pennyweight
20 pennyweights	=	1 ounce
12 ounces	=	1 pound

Avoirdupois Weight.

16 drams	=	1 ounce	4 quarters	=	1 hundredweight
16 ounces	=	1 pound	20 hundredweights	=	1 ton
14 pounds	=	1 stone	2240 pounds	=	1 long ton
28 pounds	=	1 quarter	2000 pounds	=	1 short ton

Lineal Measure.

12 inches	=	1 foot	5280 feet	=	1 land mile
3 feet	=	1 yard	6080 feet	=	1 nautical mile
6 feet	=	1 fathom	1760 yards	=	1 land mile
$5\frac{1}{2}$ yards	=	1 rod or pole	3 miles	=	1 league
40 poles	=	1 furlong	600 feet	=	1 cable
8 furlongs	=	1 mile	10 cables	=	1 admiralty mile

$69\frac{1}{9}$ land miles or 60 nautical miles make 1 degree (1°), which is one three hundred and sixtieth part of the earth's circumference. Nautical miles $\times 1{\cdot}151$ = statute miles.

Surveyor's Land Measure

In measuring land, surveyors use a **chain** (called Gunter's chain) which is 22 yards long and is subdivided into 100 equal parts, each of which is called a link.

Thus 100 links	=	1 chain	=	22 yards
10 chains	=	220 yards	=	1 furlong

Square Measure.

144 sq. inches	=	1 sq foot	40 perches	=	1 rood
9 sq. feet	=	1 sq yard	4 roods	=	1 acre
$30\frac{1}{4}$ sq yards	=	1 sq. rod, sq. pole or perch	4840 sq. yards	=	1 acre
			640 acres	=	1 sq. mile

Cubic or Solid Measure

1728	cubic	inches	=	1 cubic foot
27	,,	feet	=	1 cubic yard
40	,,	feet	=	1 shipping ton merchandise
35	,,	feet	=	1 ton sea water
36	,,	feet	=	1 ton fresh water
40 to 43	,,	feet	=	1 ton coal
100	,,	feet	=	1 ton register (ships)

Liquid Measure.

4 gills	= 1 pint	54 gallons	=	1 hogshead	=	$1\frac{1}{2}$	barrels
2 pints	= 1 quart	72 gallons	=	1 puncheon	=	2	barrels
4 quarts	= 1 gallon	108 gallons	=	1 butt	=	3	barrels
36 gallons	= 1 barrel						

$6\frac{1}{4}$ gallons = 1 cubic foot fresh water = $62\frac{1}{2}$ lbs.
10 pounds = 1 gallon fresh water
224 gallons = 1 ton fresh water
1 cubic foot sea water = 64 lbs.

Dry Measure.

2 pints	=	1 quart	4 pecks	=	1 bushel
4 quarts	=	1 gallon	8 bushels	=	1 quarter
2 gallons	=	1 peck	5 quarters	=	1 load

Measures of Time.

60 seconds	=	1 minute	23h. 56m. 4s.	=	1 sidereal day
60 minutes	=	1 hour	365 days	=	1 year
24 hours	=	1 solar day	366 days	=	1 leap year

Angular Measure.

60 seconds (″)	=	1 minute	360 degrees (°) = 1 circle
60 minutes (′)	=	1 degree	180 degrees (°) = πr = $3{\cdot}1416r$
90 degrees (°)	=	1 quadrant	

Circumference of the earth = 24,855 miles (approx.)
Diameter of the earth = 7900 miles (approx.)

METRIC SYSTEM OF MEASUREMENT.

The metric system of measurement was first introduced by the French, and is now adopted by most European countries. The lineal measure is based on the length of the metre, which is one ten-millionth part of the distance from the equator to the pole, 3·281 feet.

The units of length, capacity and weight are called the *metre, litre.* and *gramme* respectively. Multiples of these units are obtained by prefixing to them the Greek words *deca* (10), *hecto* (100), and *kilo* (1000), the divisions being obtained by prefixing the Latin words *deci* ($\frac{1}{10}$), *centi* ($\frac{1}{100}$), and *milli* ($\frac{1}{1000}$). These prefixes form the key to the entire system.

Measures of Length.

		1 millimetre	=	0·039	inches
10 millimetres	=	1 centimetre	=	0·394	inches
10 centimetres	=	1 decimetre	=	3·937	inches
10 decimetres	=	1 metre	=	39·371	inches
10 metres	=	1 decametre	=	10·936	yards
10 decametres	=	1 hectometre	=	109·363	yards
10 hectometres	=	1 kilometre	=	1093·63	yards

Measures of Volume and Capacity.

		1 millilitre	=	0·061	cubic inches
10 millilitres	=	1 centilitre	=	0·61	cubic inches
10 centilitres	=	1 decilitre	=	6·10	cubic inches
10 decilitres	=	1 litre	=	61·02	cubic inches
10 litres	=	1 decalitre	=	0·353	cubic feet
10 decalitres	=	1 hectolitre	=	3·53	cubic feet
10 hectolitres	=	1 kilolitre	=	35·31	cubic feet

1 litre is equal to the volume occupied by 1 cubic decimetre.

Measures of Weight.

		1 milligram	=	0·0154	grains
10 milligrams	=	1 centigram	=	0·154	grains
10 centigrams	=	1 decigram	=	1·54	grains
10 decigrams	=	1 gramme	=	15·43	grains
10 grammes	=	1 decagram	=	154·32	grains
10 decagrams	=	1 hectogram	=	0·22	lbs. avoirdupois
10 hectograms	=	1 kilogram	=	2·204	lbs. avoirdupois
1000 kilograms	=	1 ton	=	2204	lbs. avoirdupois

1 gramme is the weight of 1 cubic centimetre of pure distilled water at a temperature of 39·2° F.

N

MISCELLANEOUS SHIP WEIGHTS AND MEASUREMENTS

Metals.			Woods.		
Steel	489 lbs	per cubic foot	Oak	34 lbs.	per cubic ft.
Copper	550	,,	Pitch pine	40	,,
Zinc	445	,,	Elm	45	,,
Lead	712	,,	Teak	50	,,

SHIP LIFE-BOATS.

$L \times B \times D \times$ Coefficient = cubic capacity. Average coefficient = ·6
Cubic capacity ÷ 10 = maximum number of persons to carry
,, = volume of buoyancy tanks in feet

CARGO SHIPS MUST CARRY—

Life-boats under davits on each side to accommodate all hands.

Life-buoys.—Six painted white and red, at least 3 fitted with self-ignition lights, one buoy to be carried on each side of the bridge and one on each side of the ship with a 15-fathom life-line attached to it.

Tests.—Life-buoy to float 32 lbs. of iron in F.W. for 24 hours.
Life-belt to float $16\frac{1}{2}$ lbs. of iron in F.W. for 24 hours.

MATERIALS.

Chain.—Breaking strength about $30D^2$ where D is the diameter.
Proof load ,, $12D^2$
Safe working load ,, $6D^2$

Wire.—Breaking strength about $2C^2$ for 12 wires per strand.
,, ,, $3C^2$ 24 ,,
,, ,, $3\frac{1}{4}C^2$ 37 ,,
Working load about one-sixth the breaking strength.

Manila.—Ultimate strength about $\frac{1}{3}C^2$ and one-sixth ultimate strength is a safe working load; $\frac{1}{7}C^2$ for occasional lifts.

Purchases.—General equation. $S \times P = W + \frac{nW}{10}$ where S is the pull on hauling part, P the theoretical power of the purchase, W the weight to be lifted, n the number of sheaves in the purchase.

STOWAGE FACTORS.

The stowage factor is the average cubic space occupied by 1 ton weight of cargo as stowed on board the ship after making reasonable allowance for broken stowage, dunnaging and the packing of the goods. We give some of those approximate figures here for a few of the more common class of goods, based on experience of shipments.

Stowage Factors in Cubic Feet per Ton Weight.

Bags.—Nitrate 34, Cement 35, Guano 40, Sugar 42, Meal 45, Flour 45. Beans 50, Rice 50/70, Seeds 50/90, Ginger 60/80, Coconuts 100, Nuts 180/200

Bales.—Gunnies 65, Jute 65, Rubber 65, Linoleum 70, Cotton 80, Hemp 90/100, Coconut Fibre 100, Esparto Grass 100, Flax 100/150, Bark 140, Cork 300/400

Barrels.—Beer 55, Flour 60, Greases 62, Oils 60/65, Whisky 66/72, Apples 100.

Bulk.—Steel 12, Ores 12/20, Railway Iron 15, China Clay 24, Patent Fuel 35, Coal 40/45, Wheat 47, Copra 75, Coke 90.

Cases.—Dates 45, Figs 50, Currants 50, Canned Goods 60, Preserved Meats 60, Wines 60/65, Rubber 70, Coconut 70, Beer 70, Apples 90, Cinnamon 100, Nuts 120, Matches 100/120, Eggs 100.

Casks.—Cement 40, Molasses 55.

Drums.—Gasoline 60, Oils 70.

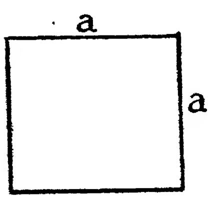
Glass 50.

Paper in Rolls 90.

Oil in bulk varies from about 36 to 43 cubic feet per ton depending upon the specific gravity and temperature of the oil.

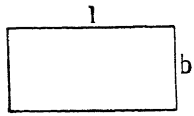
GEOMETRICAL FIGURES.

The **Perimeter** of a figure is the sum of all its sides and **is** designated by the letter ***s***.



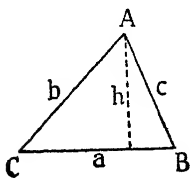
Square.—

Perimeter $=4a$
Area = side squared $=a^2$



Rectangle.—

Area=length × breadth=$l \times b$



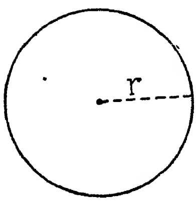
Triangle.—

(i) Area=half base × height=$\frac{1}{2}\, a \times h$

(ii) area=$\sqrt{s(s-a)\ (s-b)\ (s-c)}$

where $s=\frac{1}{2}\ (a+b+c)$

(iii) area=$\frac{1}{2}\, a\, b \sin C=\frac{1}{2}\, a\, c \sin B$



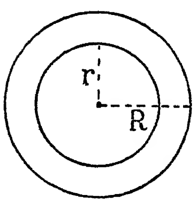
Circle.—

Circumference=$2\pi r$

$\pi=3{\cdot}1416$, or $\frac{22}{7}$ approximately

r is the radius of the circle

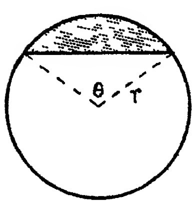
Area=πr^2



Ring.—

Area=$\pi\ R^2-\pi r^2=\pi\ \ (R^2-r^2)$

$=\pi\ \ (R+r)\ \ (R-r)$

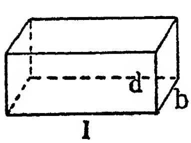


Arc of Circumference $= \dfrac{r \times \theta^\circ}{57{\cdot}3^\circ}$

Area of Sector $=\frac{1}{2}\, r^2\, \theta$

Area of Segment $=\frac{1}{2}\, r^2\, (\theta-\text{Sin}\ \theta^\circ)$

where $\theta = \dfrac{\theta^\circ}{57{\cdot}3}$



Box-shaped body.—

The surface area is the sum of the areas of its six sides.

Area=top+bottom+2 sides+2 ends

Volume=length × breadth × depth=$l \times b \times d$

Cylinder.—

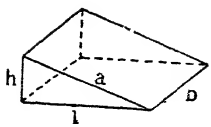
Area=areas of ends+area of curved surface

Volume=$\pi r^2 l$

πr^2=area of the end and l=length

Barrel.—

Volume=$\pi r^2 l$, where r is the mean of the end radius and bilge radius, and l the length of the barrel

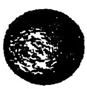


Wedge.—

Area=areas of top + bottom+end+both sides

Volume=$\frac{1}{2}$ (length×breadth×height)

$=\frac{1}{2}(l\times b\times h)$



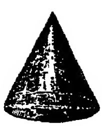
Sphere.—

Area=$4\pi r^2$

Volume $=\frac{4\pi r^3}{3}$

Volume of the shell of a hollow sphere

$=\frac{4}{3}\pi(R^3-r^3)$



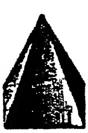
Cone—

Area of surface=curved surface+base

$=\pi r l+\pi r^2$

where l=slant height

Volume=area of base × $\frac{1}{3}$ perpendicular height



Pyramid.—

Area=sum of areas of triangles of which it is composed+area of base

Volume=area of base × $\frac{1}{3}$ perpendicular height; the same as for a cone

Triangular Prism.—

Area=area of ends+area of sides

Volume=area of base×height

Example.—Required the capacity in gallons and tons of fresh water of a tank measuring 16 ft. $\times$6 ft. $\times$10 ft.

Volume$=16\times6\times10=960$ cubic ft.
Capacity in galls $=960\times6\frac{1}{4}=6000$ galls.
Capacity in tons$=960\div36=26\frac{2}{3}$ tons

Example.—How many lbs. of mixed black paint would be required to give one coat to a funnel 50 ft. long and 20 ft. in diameter, if 1 lb of mixed paint covers 70 square ft.

Area of funnel=circumference $\times$length

,, $=2\,\pi\,r\times l$

,, $=\frac{2}{1}\times\frac{22}{7}\times\frac{10}{1}\times\frac{50}{1}$

,, $=3143$ sq. ft.

Weight of paint$=\frac{3143}{70}=44\ 9$ lbs.

Example.—A topside trimming tank is uniformly triangular in shape throughout its length. The end measures 12 ft. $\times$10 ft. $\times$14 ft. and the tank is 30 ft. long; find its capacity in tons of salt water.

Volume=area of end $\times$length

,, $=\sqrt{s\,(s-a)\,(s-b)\,(s-c)}\times l$

,, $=\sqrt{18\times6\times8\times4}\times30$

,, $=58{\cdot}8\times30$

,, $=1764$ cub. ft.

Capacity$=\frac{1764}{35}=50{\cdot}4$ tons

Example.—Find the reserve buoyancy in salt water of a barrel 4 ft. 1 in. long, end diameter 20 in., bilge diameter 28 in. and weighing 50 lbs.

Volume$=\pi\,r^2\,l$

,, $=\frac{22}{7}\times\frac{12\times12}{1}\times\frac{49}{1}=12{\cdot}83$ cub. ft.

An equal volume of water supports $12{\cdot}83\times64 = 821$ lbs.
Weight of barrel - - - - - - = 50 ,,
Reserve buoyancy - - - - - - = 771 ,,

Example.—Find the space required to stow—

(i) 100 rolls paper, length 36 in., diameter 32 in.
(ii) 400 tons sugar in bags, stowage factor 42
(iii) 200 bales, 4 ft. $\times$2 ft. $\times$2 ft. 6 in.
(iv) 1000 cases, stowage factor 60

If the freight is 35s. per shipping ton measurement less 5 per cent. required the net freight.

(i) Paper, volume $\pi r^2 l = \frac{22}{7} \times \frac{16 \times 16}{1} \times \frac{36}{1} \times \frac{1}{1728}$
$= 1676$ cub. ft.

(ii) Sugar volume	400×42	$= 16{,}800$
(iii) Bales ,,	$200 \times 4 \times 2 \times 2{\cdot}5$	$= 4000$
(iv) Cases ,,	1000×60	$\times$ 60,000

Divide by 40)82,476 cub. ft.

Shipping tons measurement 2061·9 tons

2062 tons at 35s. - - - -	£3608	10	0
less 5 per cent. - - =	180	8	6
Net freight - - - - - -	£3428	1	6

Example.—A compartment measures 10,000 cubic feet and is to be filled with a total weight of 400 tons made up of bales stowing at 60 cubic feet per ton and pig lead stowing at 10 cubic feet per ton. Required the maximum tons and cubic capacities of each that could be stowed in the compartment.

This involves a simultaneous equation. Let x = the bales and y the lead, then (i) $x + y = 400$ tons weight
and (ii) $60\,x + 10\,y = 10{,}000$ tons measurement

multiply (i) by 10 $10\,x + 10\,y = 4000$

subtract $50\,x = 6000$

$x = 120$ tons bales

$x + y = 400$

$y = 280$ tons lead

120 tons bales $\times$ 60 = 7200 cubic feet
280 tons lead $\times$ 10 = 2800 ,, ,,

Example.—How many square feet of plating are required to make a rectangular tank 10 feet long, 6 feet broad, 4 feet high? (Add 10 per cent. for overlapping edges)

Area =2 sides+2 ends+top and bottom
,, =(2×10×4)+(2×6×4)+(2×10×6)
,, = 80 + 48 + 120
,, = 248
add 10 per cent. 24·8

Total 272·8 square feet

See *Nicholls's Concise Guide*, Volume I., Chapter IV., for further Examples and Exercises in Mensuration.

SIMPSON'S RULES ARE METHODS FOR MEASURING THE AREAS ENCLOSED BY PARABOLIC CURVES.

As ship-shape curves very closely resemble parabolic curves no appreciable error is introduced by utilising Simpson's Rules in calculating areas and volumes of vessel's waterplanes and cubic capacities In measuring the area of a waterplane it is usual to calculate the half area first and multiply the result by two. The centre line of the waterplane is first drawn to any convenient scale and this is divided into an equal number of parts by an odd number of ordinates.

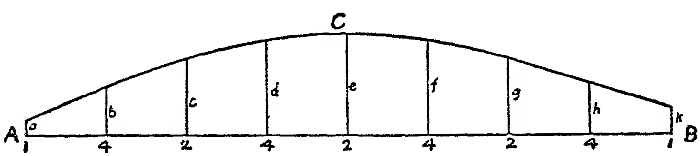


Fig. 1.

Simpson's First Rule.—In Fig. 1 *A B* represents the midship line of the waterplane; lines denoted by the letters *a*, *b*, *c*, *d*, etc., are the distances from the midship line to the edge of the waterplane *A C B* and are termed ordinates. The spaces between these ordinates are all equal and are termed the "common interval." To find the area of *A B C* we multiply the first ordinate by 1, and the last ordinate by 1 and the intermediate ordinates by 4 and 2 successively; thus, if we had

only three ordinates the multipliers would be 1—4—1; if we had five ordinates 1—4—2—4—1; and if more than five 1—4—2—4—2—4—1.

The sum of these products multiplied by one-third of the common intêrval gives the area enclosed by the curved line *A C B* and, as this is half the vessel's waterplane, by doubling it we obtain the area of the whole waterplane.

An easy way to remember the multipliers is to write the figures 1, 4, 1 in groups of three against the ordinates as follows:—

```
    1—4—1   1—4—1
        1—4—1   1—4—1
    ─────────────────
add 1—4—2—4—2—4—2—4—1
```

and these are the multipliers for the respective ordinates.

Example—Find the area of the waterplane of a barge, given length of waterplane=124 feet. Ordinates in feet=3, 10, 16, 19 5, 21, 19, 15·5, 10, 6. As we have nine ordinates given, the common interval is one eighth of the length=15·5 feet, thus in Fig. 1 the distance between *a* and *b* and between *b* and *c*=15·5 feet. The calculation of the area *A C B* is then carried out as follows:—

Ordinate	Length of Ord.	Simpson's Multipliers	Products
a	3·0	1	3·0
b	10·0	4	40·0
c	16·0	2	32·0
d	19·5	4	78·0
e	21·0	2	42·0
f	19·0	4	76·0
g	15·5	2	31·0
h	10·0	4	40·0
k	6·0	1	6·0
			348·0

$$\text{Area of } A\ C\ B = \frac{348 \times 15{\cdot}5}{3} = 1798 \text{ square feet}$$

$$\text{Area of waterplane} = 1798 \times 2 = 3596 \text{ square feet}$$

Simpson's Second Rule.—Is applied when the area is divided into a specific number of equidistant ordinates which must be 4 or 7 or 10 or

13, etc., and placing against the ordinates the figures 1, 3, 3, 1, in groups of four as follows:—

1—3—3—1 1—3—3—1
1—3—3—1

add 1—3—3—2—3—3—2—3—3—1

and these are the multipliers for the successive ordinates.

The length of each ordinate is multiplied by its respective multiplier and the sum of the products multiplied by three-eighths of the common interval gives the area enclosed by the curves. When half the section only is treated the result will be half the area of the total surface enclosed.

Example.—The lengths of the half ordinates of a transverse bulkhead in feet are 20, $18\frac{1}{3}$, 17, 15, 13, 9 and 4 respectively, the common interval between them being 4 feet. Required the total area of the bulkhead.

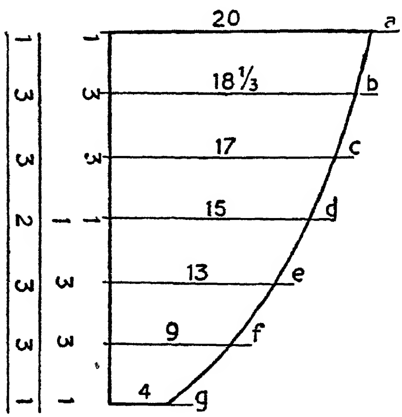


Fig. 2.

Ordinates		Multip.	Products
a	20 ft.	1	20
b	$18\frac{1}{3}$	3	55
c	17	3	51
d	15	2	30
e	13	3	39
f	9	3	27
g	4	1	4
Sum of products for half area			226

Total area $= 226 \times \frac{3}{8} \times 4 \times 2$
$= 678$ sq. ft.

Example.—Suppose we were asked to find the volume of the vessel, outlined in Figure 3, enclosed between bulkheads *a* and *e* which are each spaced 30 feet apart. We would, in the first instance, find the half area of each bulkhead from its figured dimensions, as indicated in the previous example, either by Simpson's First or Second Rule whichever we found most convenient.

Let these areas be as follows:—

Bulkhead	*a*	*b*	*c*	*d*	*e*
Area in sq. ft.	100,	350,	630,	450,	200

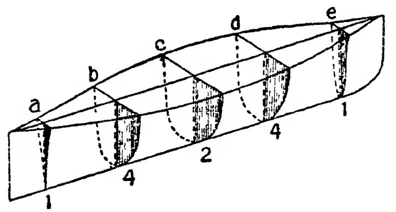


Fig 3.

The area of each bulkhead now becomes the ordinate in finding the cubic capacity and, as there are five of them, the 1—4—1 rule will apply, the work to be arranged in the following order.

	½ Ordinates	Multipliers	Products
a	100	1	100
b	350	4	1400
c	630	2	1260
d	450	4	1800
e	200	1	200
			4760

$$4760 \times \frac{30}{3} = 47{,}600 \text{ cub. ft.}$$

$$\times 2$$

Total volume 95,200 cub. ft.

The displacement of this volume in salt water would be 95200÷35=2720 tons.

A closer spacing of the bulkheads, or rather, ordinates, as it is not necessary to actually build in the transverse areas and we have merely shown them in the figure to help out our explanation, a closer spacing would give a closer approximation to the actual volume.

Shipbuilders, however, prefer to calculate the enclosed volume of a considerable part of a ship by using horizontal transverse sections rather than vertical transverse sections as in the preceding example.

Simpson's Rules are based on the assumption that the boundary of the curvilinear area conforms to a parabolic curve, so that results will be only approximately correct when the curve departs from a parabola.

EXAMPLES FOR EXERCISE.

1. The external and internal diameters of a steel tube 14 feet long are 12 inches and 10 inches respectively, find (1) the volume of the enclosed space, (2) the volume of the steel forming the tube, (3) the weight of the tube, the specific gravity of steel being 7·84

2. An awning is 25 feet long and 15 feet wide, find its area and the length of the rope round its edges.

3 A jib is laid flat on deck. The foot measures 20 feet long and the length from foot to head, measured perpendicular to the foot, is 40 feet. Required the number of square yards of canvas in the sail.

4. A boat's standing lugsail has the following measurements:—Head 10 feet, luff 8 feet, foot 12 feet, after leach 16 feet, diagonal from throat to clew 14 feet. What is the area of the lugsail?

5. A prohibited area, triangular in shape, is marked off in a harbour by three buoys, *A*, *B* and *C*. The distance from *A* to *C* is 300 yards, from *B* to *C* 400 yards, and the horizontal sextant angle at buoy *C* subtended by the buoys *A* and *B* is 45°. Required the area of the enclosed space.

6. Find the surface area of a rectangular case measuring 6 feet long, 3 feet broad and 2·5 feet deep.

7. Find the surface area of an oil drum 2 feet high, its diameter being 1 foot.

8. Find the total surface area of a wedge of height 3 feet, slant length 5 feet, base length 4 feet, breadth 2 feet.

9. Find the volume of a tank 10 feet long, 8 feet broad and 20 feet deep How many gallons of fresh water will it hold?

10. Find the volume of a cylinder whose length is 12 feet and diameter 6 feet. Refer to the figure of a cylinder.

11. Find the gallons of fresh water contained in a barrel 3 feet long whose bilge diameter is 2 feet and head diameter $1\frac{1}{2}$ feet.

12. A wedge-shaped heap of coal is piled up in a ship's hold against a bulkhead to a height of 10 feet and extending along the ceiling for 15 feet, the breadth being 30 feet. Find how many tons there are, assuming 42 cubic feet to the ton.

13. A ship sails a circular course round a point and maintains a constant distance of 4 miles from it until the point alters its bearing 49°. Required the distance sailed.

14. The barrel of a wire reel is 3 feet in diameter and $3\frac{1}{2}$ feet long. Find (*a*) how many turns of a 3-inch wire will go on the drum to complete a single layer, (*b*) what length of wire will be in the layer?

15 The paddle wheels of a steamer are 21 feet in diameter and make 2000 revolutions. How many nautical miles did the ship go, neglecting slip?

16. The outer and inner radii of a hollow spherical shell are 8 inches and 7 inches respectively. Find the volume of the shell.

17. The diameter of a cylinder is 14 inches. What length of steel bar is required to form a ring to fit inside of it?

18. A ship in rounding a point maintains a constant distance of 3 miles from it whilst the bearing of the point alters 65°. What distance in miles did she sail?

19. There are 20 turns of wire on the barrel of a winch the diameter of which is 28 inches. Find the length of the wire in feet.

20. A ship on steaming trials is turning in a circle on port helm. She takes $6\frac{1}{2}$ minutes steaming at 5 knots to complete the circle. Find (*a*) the distance travelled by the ship; (*b*) the diameter of her turning circle.

21. A barrel 3 feet long, bilge diameter 24 inches, end diameter 18 inches, weight of barrel 35 lbs. Required its reserve of buoyancy in salt water.

22. Eggs and butter are to be stowed in a cold storage chamber measuring 15 ft. × 20 ft. × 25 ft., the eggs in crates stowing at 100 cubic feet per ton and the kegs of butter at 60 cubic feet per ton. If the combined weight of the eggs and butter is 90 tons, required the maximum quantity of each that can be put into the chamber.

23. A marine boiler is 16 ft. $1\frac{1}{2}$ ins. internal diam. × 12 ft. 6 ins. long. The furnaces, tubes, etc., occupy 26 per cent. of the volume and the steam space 30 per cent. of the volume, calculate how many tons of fresh water the boiler requires to fill it to the working level, and how long will it take to fill the boiler to this level if the pipe delivers 150 gallons per minute.

24. The pontoon of a floating dock is 560 feet long, 100 feet beam, and the draft in S.W. with a ship in the dock is 14 ft. 6 ins. there being 600 tons of water in the tanks of the dock. If the weight of the dock with complete equipment and tanks empty is 12,050 tons, find the weight of the ship.

25. Find by Simpson's First Rule the area of a deck 126 feet in length, the ordinates being 4, 20, 24, 32, 28, 26 and 6 feet, and the common interval between them 21 feet.

26. Required the area of the following waterplane 150 feet long, common interval 25 feet, half ordinates 5, 10, 12, 14, 11, 8 and 4 feet.

27. Given the following areas of transverse sections with a common interval of 20 feet, find by Simpson's First Rule the tons displacement in salt water: Areas 28, 140, 176, 235, 293, 235, 176, 140, 11 feet respectively.

ANSWERS.—MENSURATION

1. 7·64 cubic feet, 3·36 cubic feet. 1646·9 lbs.
2. 375 square feet. 80 lineal feet.
3. $44\frac{4}{9}$ square yards.
4. 117·2 square feet.
5. 42,433 square yards.
6. 81 square feet.
7. $7\frac{6}{7}$ square feet.
8. 36 square feet.
9. 1600 cubic feet. 10,000 gallons.
10. $339\frac{3}{7}$ cubic feet.
11. 45·11 gallons.
12. $53\frac{4}{7}$ tons.
13. 3·42 miles.
14. 44 turns, $414\frac{6}{7}$ feet.
15. 21·7 miles.
16. ·41 cubic feet.
17. 44 inches.
18. 3·4 miles.
19. 146·6 feet.
20. (*a*) 3293 feet; (*b*) 1048 feet.
21. 427 lbs.
22. Eggs $52\frac{1}{2}$ tons, Butter $37\frac{1}{2}$ tons.
23. 31·2 tons at 36 cubic feet per ton 47 minutes.
24. 10,550 tons.
25. 2982 square feet.
26. 3050 square feet by 1st Rule. 3000 square feet by 2nd Rule.
27. 28,860 cubic feet. 824·6 tons.

CHAPTER XV.

HYDROSTATICS.

The Hydrometer.—The hydrometer is an instrument for finding the relative density or specific gravity of liquids. The name is derived from two Greek words, *hydor* (water) and *metro* (measure).

The Principle of the hydrometer is based on the law of Archimedes, which states that "all floating bodies displace a quantity of liquid equal to their own weight."

Construction.—The marine hydrometer consists of a glass cylinder with a bulb on its lower end containing mercury or small shot to act as ballast to keep the instrument upright when floating. The cylinder supports a stem which carries the scale. The volume of the cylinder is about 25 times the volume of the stem. Glass is the best material for use in salt water. If the hydrometer were made of metal it might become corroded by the action of the salt, and its indications would be erroneous. Even when made of glass it must be kept scrupulously clean and all smears or greasiness removed by wiping the instrument with a clean soft cloth before and after use.

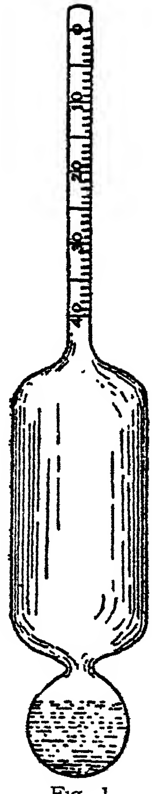


Fig 1.

The Scale is graduated from 0 at the top to 25 or 40 at the bottom. The simplest form of hydrometer, but one inconveniently long, would consist of a rod of uniform bore, and the longer and thinner the rod the greater would be its sensibility in detecting differences of density as measured by the scale, the graduations of which would be proportional to the volume of the rod and inversely proportional to its cross sectional area. The marine hydrometer expresses equal differences of density for successive divisions, hence the reason why the graduations become closer towards the lower end of the scale.

The scale indicates the specific gravity of the liquid in which the

instrument is floating. If the reading were 24, the specific gravity would be 1·024 and its density 1024 ounces per cubic foot. When floating in pure fresh water the scale indicates 0, which means the density or weight of the liquid is 1000 ounces per cubic foot, or density 1000 ounces per cubic foot. The density of salt water varies in different parts of the world. In some parts of the Suez Canal where the water is very salt (the Bitter Lakes) it may be 40 or even higher. In the vicinity of large fresh water rivers the density of the adjoining sea water might be less than the density of average "sea water," which is accepted as having a specific gravity 1·025, or density 1025 ounces per cubic foot.

To Use the Hydrometer.—Draw a bucketful from over the side, making sure that it is not affected by any discharges from the ship. Place the hydrometer in and spin it round slightly in the centre of the bucket. When it has lost its up and down motion, and the turning motion has nearly ceased, the reading on the scale will indicate the specific gravity. The temperature should be noted before the reading for specific gravity is taken.

A Standard Temperature of 59° Fahrenheit has been adopted for marine hydrometers to which all observations should be reduced. When the water being tested differs from 59° Fahr. a correction to the reading is necessary if accurate results are required. A Table of Corrections is given in the *Barometer Manual.*

The Density of a substance is its weight per unit volume.

$$\text{Density} = \frac{\text{weight of substance}}{\text{volume of substance}}$$

Specific Gravity or "relative density" of a substance is the number of times that any volume of the substance is heavier than an equal volume of pure fresh water at a temperature of 4° Centigrade.

$$\text{Specific gravity} = \frac{\text{weight of substance}}{\text{weight of equal volume of water}}$$

The density of fresh water may be expressed as

1000 ounces per cubic foot
or 62½ lbs. per cubic foot
or 1 gramme per cubic centimetre
or 1 ton per 36 cubic feet

whatever units of weight and volume are selected.

The density of average sea water is 1025 oz. per cubic foot or 64 lbs per cubic foot, but the

$$\text{Specific gravity of sea water} = \frac{\text{weight of 1 cub ft sea water}}{\text{weight of 1 cub. ft. fresh water}}$$

$$\text{,,} \quad = \frac{1025}{1000} = 1{\cdot}025$$

The density of mercury is 849 lbs per cubic foot and the

$$\text{Specific gravity of mercury} = \frac{(849 \times 16)\text{ oz. per cub. ft.}}{1000\text{ oz per cub. ft.}}$$

$$\text{,,} \quad = 13{\cdot}6$$

BUOYANCY.

Buoyancy is due to the supporting power of the water. All bodies when immersed in water exhibit an "apparent" reduction in weight. Everybody experiences this sensation when lying in a bath of water and Archimedes has the credit of being the first man to establish and to apply the theory in practice.

It is necessary to recall to mind the following information when working examples on buoyancy.

1 cub. ft. fresh water	= $62\frac{1}{2}$ lbs. = 1000 oz.
1 cub. ft. salt water	= 64 lbs.
2240 lbs.	= 1 ton
224 gallons	= 1 ton fresh water
1 ton fresh water	= 36 cub. ft.
1 ton salt water	= 35 cub. ft.
1 cub. ft.	= 1728 cub. ins.

Experiment.—Find the volume of an object, say a sphere, $\frac{4 \pi r^3}{3}$ (*see* "Mensuration," page 349). Suspend the sphere from a spring balance, as in Figure 2 and note its weight. Immerse the sphere in

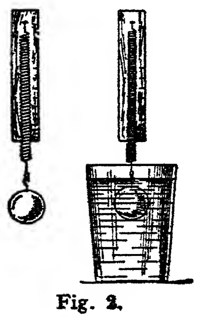


Fig. 2.

fresh water and weigh it again. The spring balance will register less than before.

Example.—A sphere of radius 2 inches weighs 40 ounces in air, what will it weigh when suspended in water?

$$\text{Volume} = \frac{4\,\pi\,r^3}{3} = \frac{4}{1} \times \frac{22}{7} \times \frac{8}{3} = 33{\cdot}52 \text{ cubic inches}$$

$$\text{Volume } 33{\cdot}52 \text{ cub. ins. water} = \frac{33{\cdot}52 \text{ in.} \times 1000 \text{ oz.}}{1728 \text{ in.}} = 19{\cdot}4 \text{ oz.}$$

Sphere, volume 33·52 cub. ins. weighs		40·0 ounces in air
Water, volume ,, ,,		19·4 ounces
The sphere weighs in water	- -	20·6 ounces

Example.—A block of concrete weighing 2 tons and measuring 30 cubic feet is lowered by a crane into sea water, what weight is the crane then supporting?

Weight of block in air (2×2240)	=	4480 lbs.
30 cub ft. salt water supports (64×30)	=	1920 ,,
Weight of block in water - -	=	2560 lbs.

Another way of setting this type of question would be to say that a block, 30 cubic feet and of density 149·33 lbs. per cubic foot, is immersed in sea water, required its loss of weight.

$$\text{Loss of weight} = (30 \times 149{\cdot}3) - (30 \times 64)$$
$$\text{,,} \quad = 4480 - 1920 = 2560 \text{ lbs.}$$

Example.—A rectangular tank 6 ft. ×4 ft. ×3 ft. floats in fresh water, its draught being 1 foot, what does the box weigh?

Volume of displaced water	=	6 ft. ×4 ft. ×1 ft.	=	24 cub. ft.
Weight ,, ,,	=	24 ft. ×62½ lbs	=	1500 lbs.

The weight of tank is 1500 lbs.

What weight must be put into the tank to sink it 6 inches in salt water?

The weight will be equal to that of the volume of water to be displaced, viz., 6 ft. ×4 ft. ×·5 ft. =12 cub. ft.; 12 ft. ×64 lbs. =768 lbs., the weight required.

Pressure is somewhat different from density. The pressure of the water is exerted equally in every direction, upwards, downwards and sideways. The pressure of water increases at the rate of 64 lbs. per square foot of area for every foot depth of water. Think of a container, a square box on a table measuring 1 ft $\times$1 ft $\times$ 1 ft. so that the area of each side will be exactly 1 square foot. Fill the box with water.

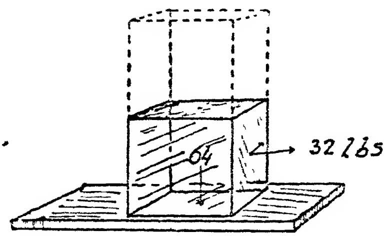


Fig 3.

The water is now pressing outwards on every side of the box. The mean pressure on each side is 32 lbs. per square foot, but this pressure is resisted by the strength of the container. The water presses downwards on the bottom of the box with a mean pressure of 64 lbs. per square foot, but this pressure is supported by the upward force of reaction exerted by the table. There is only the pressure of the atmosphere acting on the surface of the water.

If another exactly similar box be placed on top of the first the pressure exerted by the water on its sides and bottom will be the same as in the case of the lower box.

But what is now the effect on the lower box? Obviously the superimposed weight does not add to the pressure exerted by the water in the lower box, but the additional 1 cubic foot of water *does* increase the downward pressure on the bottom of it which has now to support 2 cubic feet of water, or $2 \times 64 = 128$ lbs., neglecting the weight of the boxes.

The same reasoning would apply to our box when empty and immersed in water with its top edge on a level with the surface. There would be no water pressure on the top of the box. The upward pressure at a depth of 1 foot would be 64 lbs. because the area of the bottom is 1 square foot. The mean pressure on each side would be 32 lbs., because the mid-point is 6 inches below the surface and $\cdot 5$ ft. $\times 64$ lbs. $= 32$ lbs.

If the empty container were further immersed so that its top was 1 foot below the surface then its bottom would be 2 feet down. The

pressure on the top would be 1 ft ×64 lbs.=64 lbs ; the pressure on the bottom would be 2 ft. ×64 lbs =128 lbs; the pressure on each side would be

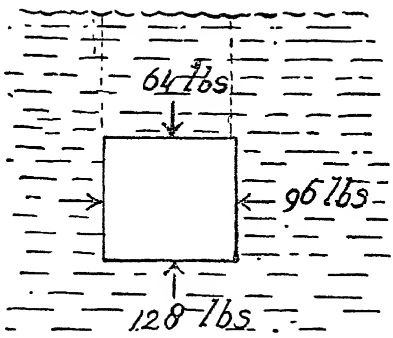


Fig. 4.

1·5 ft. ×64 lbs.=96 lbs. per square foot at any point halfway down the side of the box.

Example.—Required the pressure in tons on the bottom plating of a ship at a depth of 20 feet, the area of which is 9000 square feet.

The pressure in lbs. = 64 lbs. × area × depth.

Pressure=64 lbs. ×9000 square ft. ×20 ft.÷2240 lbs.=5143 tons.

Example.—Required the average pressure on a plate 10 ft. by 4 ft. suspended vertically in water, the top edge being 20 feet below the surface.

Area of the plate is 10 ft. ×4 ft.=40 sq. ft.

Mean depth is ½ (20+30)=25 ft.

Pressure is 64 lbs. ×25 ft. (depth) ×40 sq. ft. (area)=64,000 lbs.

Example.—The outer bottom is punctured so that a vessel is floating on her tank tops which have an area of 30 ft. ×40 ft. at a depth of 18 ft. Required the mean upward thrust of the inner bottom in tons.

Pressure=64 lbs. ×18 ft. ×1200 sq. ft.÷2240 lbs.=617 tons.

Water Pressure Tests.—Tanks are tested by a head of water usually 8 feet high. The sea-cock of the tank is opened to allow the water to run in, and if the level of the sea surface is higher than the inner bottom the water will endeavour to reach the same level inside the vessel as it is outside. If the difference of level is 8 feet the mean upward thrust on the inner side of the tank top will be 64 lbs. ×8 ft.=512 lbs. per square foot of area.

The same pressure can be obtained by means of a "stand" pipe, which is just a vertical pipe with its bottom end screwed into a hole in

the tank top. Water is then pumped into the tank until it reaches a height of 8 feet in the stand pipe. The pressure inside the tank will

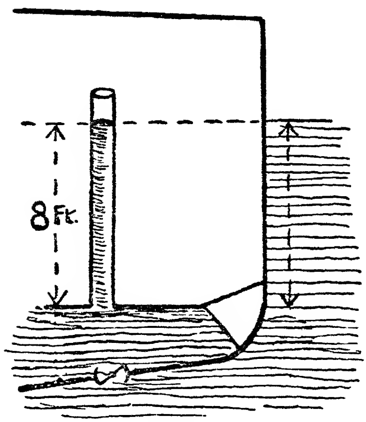


Fig 5

then be 64 × 8 = 512 lbs. per square foot. When pumping up tanks and the water overflows in the air pipes an excessive pressure is being exerted on the inner sides of the tank and the pumps should be stopped.

Example.—The level of the water in the expansion trunk of a tanker is 6 feet higher than the bottom of the summer tanks the area of which is 60 ft. × 20 ft., what is the upward thrust on the bottom of the summer tanks which happen to be empty?

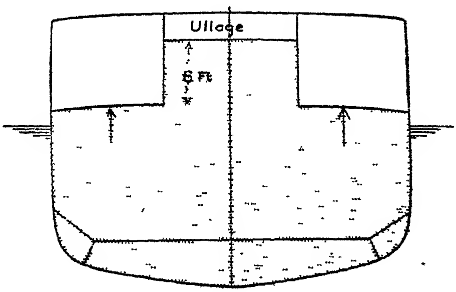


Fig. 6.

64 lbs. × 6 ft. × 1200 sq. ft. ÷ 2240 lbs. = 205·7 tons.

The question of water pressure is a serious one for a deep sea diver as the atmospheric pressure within his suit and his body has to be

adjusted by means of an air pump to withstand the collapsing pressure of 64 lbs. per square foot for every foot depth of water he descends.

Water is Non-Compressible.—Air is compressible, but water under normal conditions is not so in practice. The average pressure of the atmosphere is 15 lbs per square inch which works out at 2160 lbs per square foot, or nearly 1 ton, so that an average sized person having a surface body area of 10 square feet is built to withstand a normal pressure of about 10 tons, but the air pressure inside his body is equal to the external pressure and so he is able to carry on.

The Atmospheric Sounding Tube is based on the compressibility of the air entrapped in the glass tube, the basis being Boyle's Law, which states "that the volume of a gas varies inversely as the pressure when the temperature is constant." This may be written

$$\frac{\text{New pressure}}{\text{Old pressure}} = \frac{\text{old volume}}{\text{new volume}}$$

The sounding tubes are 24 ins. long and their bores are exactly parallel throughout their length, one end being sealed and the tube is lowered into the sea open end downwards. The air in the tube exerts a pressure of 15 lbs. per square inch, which is equivalent to the pressure exerted by water at a depth of 33 feet. The pressure

at sea surface is 1 atmosphere = 15 lbs. per sq. in.
at 33 ft. down it is 2 atmospheres = 30 ,,
at 66 ft. down it is 3 atmospheres = 45 ,, etc.

When the tube descends the pressure of the water increases and rises in the tube, thus gradually reducing the volume of the entrapped air, the minimum volume being recorded when the maximum pressure is reached, namely, on reaching the bottom. The tube records the volume by means of the discoloration; the volume gives the pressure, and the pressure gives the depth.

Example.—The volume of air left in a 24 in. tube is 6 inches after reaching the bottom, required the depth of water.

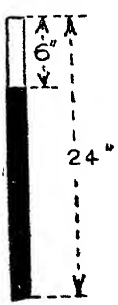


Fig. 7.

Let x represent the depth corresponding to the increase of pressure.

$$\frac{\text{New pressure}}{\text{Old pressure}} = \frac{\text{old volume}}{\text{new volume}}$$

$$\therefore \frac{x+33 \text{ ft.}}{33 \text{ ft.}} = \frac{24 \text{ ins.}}{6 \text{ ins.}}$$

$$x+33=33\times24\div6=132 \text{ ft.}$$

$$x=132-33=99 \text{ ft.}=16\tfrac{1}{2} \text{ fms.}$$

Note.—The tube starts off with an initial internal air pressure of 15 lbs. per square inch, the equivalent of 33 feet depth of water, but x represents the actual depth which we are trying to find

Example.—What would be the length of the volume of air left in a sounding tube after it has been lowered to 30 fathoms?

Volume is asked for in this example.

$$\frac{\text{New volume}}{\text{Old volume}} = \frac{\text{old pressure}}{\text{new pressure}}$$

$$\frac{x \text{ ins.}}{24 \text{ ins.}} = \frac{33 \text{ ft.}}{(180+33) \text{ ft.}}$$

$$\therefore x = 33 \times 24 \div 213 = 3 \cdot 71 \text{ inches}$$

The scale of depths for K.B B tubes is calibrated for a barometer reading of 29 0 inches. A reading higher than 29·0 indicates a higher initial pressure of air within the tube which will be harder to compress into smaller volume and will give a scale reading too low.

If barometer	reads	29 5	add a fathom	in every	40	fathoms.
,,	,,	30·0	,,	,,	30	,,
,,	,,	30·5	,,	,,	20	,,

TANK GAUGES.

The fact of the pressure of liquids increasing with the depth is applied in the application of hydrostatic gauges to measuring the height of the surface level of liquids inside tanks, the draught of a ship, the depth of water in a river at any stage of the tide, or, indeed, to the alteration of the surface level of any liquid above any desired datum level. Such apparatus is designed to convert changing pressures into scaled depths.

The Pneumercator Tank and Draught gauges manufactured by Messrs. Kelvin, Bottomley & Baird, Glasgow, consist of five essential parts shown in Figure 8 where (1) is the balance chamber, (2) an air pump, (3) the mercury gauge calibrated in feet and inches of liquid depth, (4) a control valve, (5) small solid drawn air piping led from the chamber through devious paths to the gauge.

Figure 9 illustrates a tank with the air chamber inside of it and the air pump for expelling liquid from the chamber. It is necessary to bring the level of the small residual amount of liquid that may collect

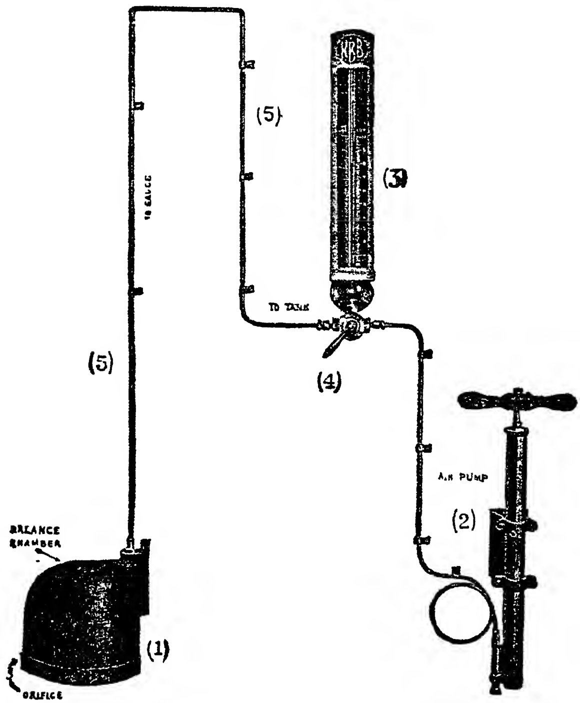


Fig. 8.—Pneumercator Tank Outfit.

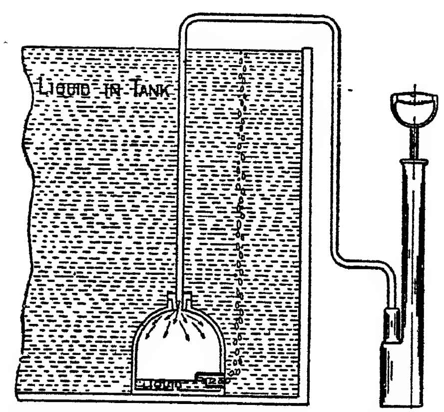
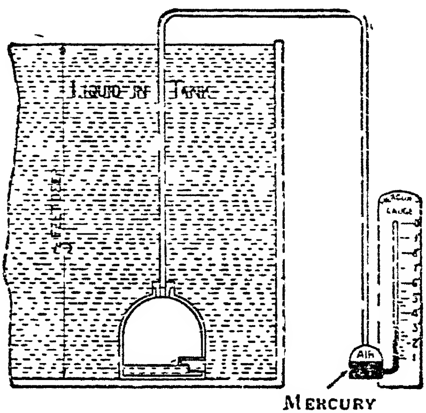


Fig. 9.—Expelling Liquid from Chamber.

in the chamber to a definite datum level, and this is effected by working the hand air pump which forces air into the chamber, the excess of back pressure pushes the liquid back into the tank through a small orifice at the datum level of the chamber from which air bubbles are seen emerging in the diagram. This preliminary operation having been performed the gauge scale will now record the depth of liquid in the tank.

The Principle is illustrated in Figure 10. The downward pressure of the liquid increases with its depth, or height, and forces its way through the orifice into the balance chamber. The entrapped air is consequently forced back through the air pipe line to a cistern of mercury at the gauge, the mercury being thus pushed back into the bore of the



TRAPPED AIR IN BALANCE-CHAMBER
COMPRESSED BY HEAD OF LIQUID IN TANK.
Fig. 10.

tube. The length of the column of mercury in the tube corresponds to the pressure of the liquid and the scale expresses this pressure in feet and inches.

If water were substituted for mercury in the gauge glass it would automatically find its own level, but a scale of the same depth dimensions as the tank would be required, the air entrapped in the pipe merely acting as a cushion and serving no useful purpose. But the specific gravity of mercury is 13·59 so that it compresses into a column 13·59 times shorter than one of fresh water when subjected to the same pressure, with a corresponding reduction in the length of the scale. For example, in Figure 10, the head of water in the tank is 3 feet and

the length of the column in a water gauge would be 3 feet, but the column in a mercury gauge would only be about 2·6 inches, namely, 36 inches divided by 13·59=2·6 inches. A control valve, (4) in Figure 8, connects the air pump with the balance chamber, or the chamber with the gauge, or disconnects all three components as required.

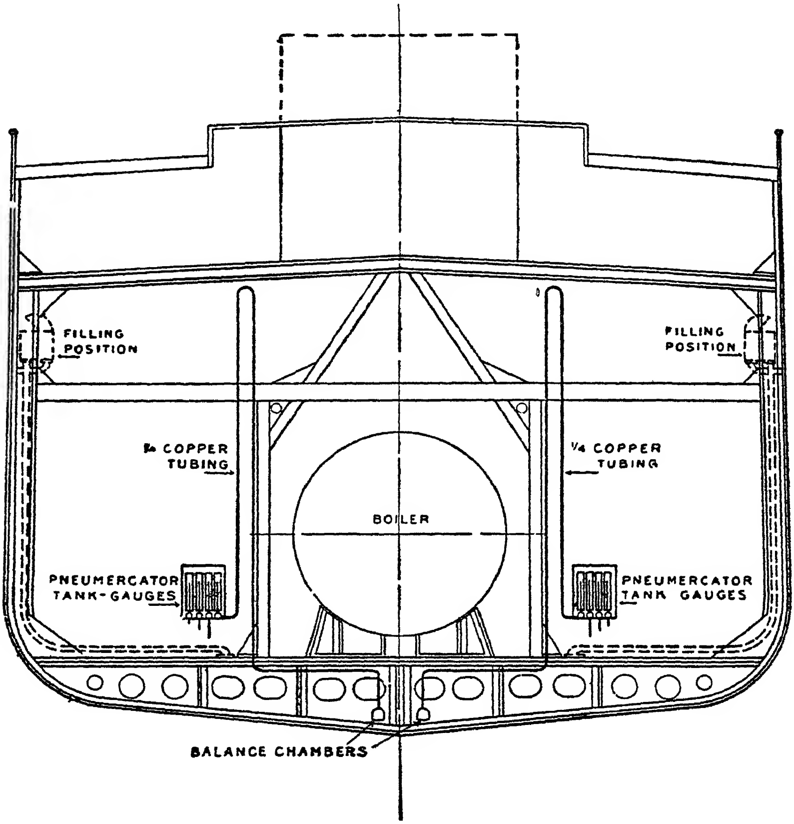


Fig. 11.—Fuel Oil Tank Gauges.

The illustration shows a typical ship installation. The balance chambers are seen in the double bottom tank, the copper air pipe is carried up above the load water line and down again to gauges in the engine-room. The filling pipes for running in oil are indicated by hatched lines.

DRAUGHT INDICATORS.

The same principle is applied to registering the draught of a ship. Two balance chambers, one forward and one aft, are placed in a convenient position against the ship's side below the level of the light load line,

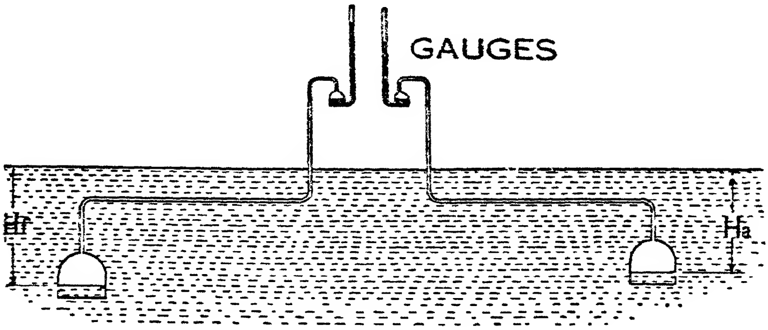


Fig 12.

as in Figure 12, which assumes the ship to be non-existent. The mercury rises and falls in the gauges whenever the draught increases or decreases and, in Figure 12, the fore gauge is being operated by the head of water *Hf*, and the aft gauge by the head *Ha*.

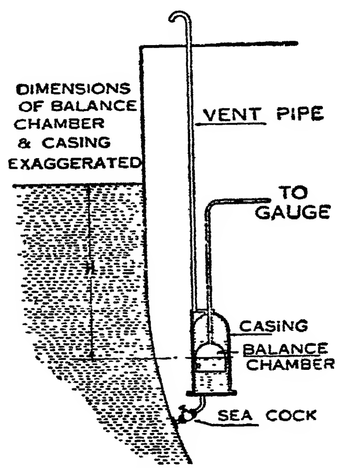


Fig. 13.—Chamber of Draught Indicator.

A structural modification is required for the balance chamber, as shown in the next Figure (13), where the balance chamber is contained

in a watertight casing connected to the sea below the light load line a 1-inch sea-cock and vented to the deck, so that, in effect, the balanc chamber is immersed in the sea at a fixed position relative to the keel

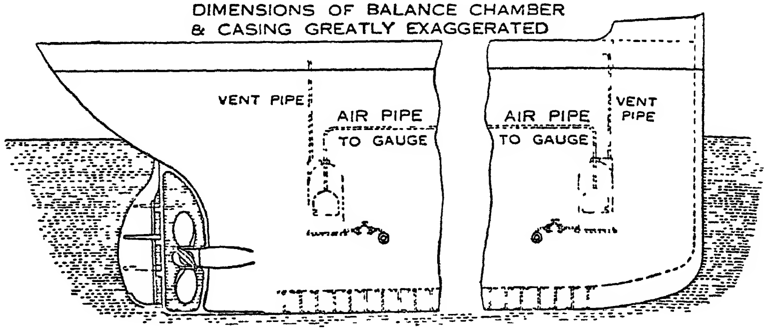


Fig 14 —Pneumercator Draught Indicators.

In the diagram the head of sea water *H* is operating the indicator. Figure 14 shows in profile the lay-out of the pneumercator draught indicators, the gauges for both fore-and-aft draughts being usually mounted side by side in any convenient position as selected.

MARKING OF A SHIP.

A ship is required to have in addition to her load line and deck line marks her name marked on each side of her bows, also her name and port of registry on her stern. The letters shall be not less than 4 inches in length, and of proportionate breadth. They must be light in colour on a dark ground, or dark in colour on a light ground. Her official number and registered tonnage must be cut in on her main beam.

A scale of feet denoting her *draught* on each side of her stem and stern post. The scale may be marked in Roman capital letters or in figures. The figures must be not less than 6 inches in length. They are generally made *exactly* 6 inches in length with a space of 6 inches between them.

The letters or figures must be cut in and painted a light colour on a dark ground or in such other way as the Board of Trade approve. The bottom of the figures indicates an even foot of draught, for example,

the bottom of the 17 feet mark indicates	17 ft.	0 ins.
half way up the 20 feet mark ,,	20	3
half way between the 21 and 22 feet marks	21	9
the top of the 24 feet mark indicates	24	6

Penalties.—If the marking is in any way inaccurate so as to be likely to mislead, the owner of the ship shall be liable to a fine not exceeding £100.

If the marks are fraudulently altered by any person, the owner, master, or person shall be liable to a fine not exceeding £100.

The load line marks are closely associated with the tonnage measurements of a ship defined as follows:—

Under deck tonnage is a measure of the internal space between the top of the ceiling or double bottom in the hold and the under surface of the tonnage deck. The unit of measurement is a ton of 100 cubic feet.

Gross tonnage is a measure of the total internal volume of the ship, and is equal to the under deck tonnage plus the tonnage of all enclosed spaces above the tonnage deck.

Net tonnage is the residual tonnage after the various allowances for propelling power, crew spaces, and navigation spaces, have been deducted from the gross tonnage

Displacement tonnage is the total quantity of water displaced by the vessel when floating at her load draught.

Deadweight tonnage is the number of tons (of 2240 lbs.) of cargo, stores, etc., that a vessel is capable of carrying when floating at her load draught.

Load waterline is the waterline corresponding to the maximum draught to which a vessel is permitted to load, either by the freeboard regulations, the conditions of classification or the conditions of service.

Draught is the distance from the lowest part of the keel to the waterline at which the vessel is floating.

Load draught is the distance from the lowest part of the keel to the load waterline as defined above.

Coefficient of Fineness is the ratio between the actual volume of the under water shape and the volume of a rectangular block having the same extreme length, breadth and depth. The coefficient is expressed as a decimal and varies from about ·5 in the case of fine lined yachts gradually increasing through ·6 to ·75 in the case of fast passenger steamers, and to ·85 for slow, bluff cargo vessels.

Displacement=length × breadth × draught × coefficient divided by 35 (cubic feet of salt water per ton) when the ship floats in sea water, and by 36 (cubic feet of fresh water per ton) when floating in fresh water.

$$\text{Displacement} = L \times B \times d \times \text{coefficient} \div 35 \text{ for sea water.}$$

1. Find the displacement of a vessel, length 500 feet, breadth 40 feet, mean draught in salt water 20 feet, block coefficient ·7.

Ans.—8000 tons.

2. A vessel 400 feet long, 30 feet beam, and 25 feet mean draught displaces 5143 tons in sea water. Find her block coefficient and state what type of vessel you think she might be.

Ans.—Coefficient ·6 A steam yacht or a very fine lined steamer.

3. Length 500 feet, breadth 50 feet, mean draught 30 feet, block coefficient ·8. Required the vessel's displacement in fresh water.

Ans.—16,666 tons.

4. Length 420 feet, breadth 45 feet, mean draught 25 feet, block coefficient ·8. Required the vessel's displacement in salt water.

Ans.—10,800 tons.

VARIATIONS IN DENSITY AND DRAUGHT.

The hydrometer is used to find the density of harbour water so that the corresponding increase in draught may be computed. The buoyancy of all floating bodies is dependent upon the law of Archimedes.

If the density of a body is exactly equal to the density of the water it will neither sink nor float; if its density be greater the body will sink, and if less it will rise until the weight of the body is equal to the weight of the volume of water it displaces. It is obvious, therefore, that a ship of a given weight will displace more fresh water than salt water because every cubic foot of fresh water can only support $62\frac{1}{2}$ lbs. weight of the ship whereas 1 cubic foot of salt water supports 64 lbs. The draught varies inversely as the density, and in the case of box-shaped vessels this may be written

$$\frac{\text{New draught}}{\text{Old draught}} = \frac{\text{old density}}{\text{new density}}$$

Example.—The mean load draught of *Caledonian Monarch* is 24 feet 5 inches in salt water, what should her draught be when loading in dock water of density 1005?

$$\frac{\text{Draught}}{\text{24 ft. 5 ins.}} = \frac{1025}{1005} \text{ from which } x\text{=24 ft. 10·8 ins.}$$

Draught in dock water	24ft.	10·8 ins
Draught in salt water	24	5·0
Difference in draught		5·8

The foregoing method is not accurate in the case of ships and other irregularly shaped bodies. A nearer approximation may be got by assuming the ship to be a hydrometer and the distance between F.W. and S.W. marks to represent the scale, the top edge of F W being 0 and the top edge of S W being 25, with the intervening distance divided up proportionately.

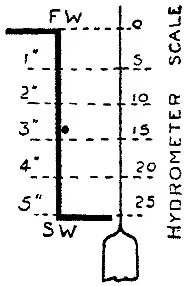


Fig. 15.

Assuming the distance between F.W. and S.W. marks to be 5 inches and to be divided into five parts corresponding to 5, 10, 15, 20 and 25 of the hydrometer scale, then, as in Figure 15, when the dock water density is 1005 the F.W. mark should be 1 inch clear of the waterline and 2 inches clear when the hydrometer reads 1010, 3 inches clear for 1015, 4 inches for 1020, and 5 inches for 1025, the density when the ship should be loaded to the top edge of the S.W. mark.

Example.—The distance between the F.W. and S.W. marks is

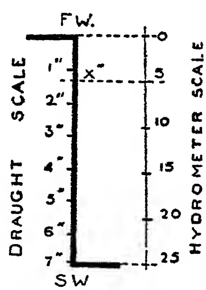


Fig. 16.

7 inches in the case of *Caledonian Monarch*, what allowance in draught would be made when loading her in dock water of density 1005?

The difference of draught is to 7 inches as the difference of density

between F.W. and the dock water (5) is to the difference between F.W. and S.W. (25)

$$\frac{x \text{ ins}}{7 \text{ ins}} = \frac{5}{25} \therefore x = \frac{35}{25} = 1{\cdot}4 \text{ ins.}$$

The F.W mark should be 1·4 inches clear of the waterline, or, the same result is to submerge the S.W. mark 5·6 inches.

The denominator in inches of the equation is a constant for each particular ship and the denominator 25 is constant for all ships.

The foregoing methods are near enough for the practical purposes of loading a ship but it is not strictly accurate for all types of ships, so the Board of Trade apply the following formula:—

$$\text{Immersion} = \frac{D \times d}{T \times 1000} \text{ inches, where}$$

D =displacement in salt water up to the centre of the disc

T =tons per inch immersion in salt water at the centre of the disc, and

d =difference between densities of salt water and the water at the place of loading

Example.—Caledonian Monarch is loading in dock water (1005), how much may her S W. mark be immersed?

Referring to her deadweight scale and supplementary notes at the end of the book we find total load displacement 13,007 tons; per inch immersion 47·1 tons; and by introducing these facts into the above formula we get

$$\text{Immersion} = \frac{13007 \times 20}{47{\cdot}1 \times 1000} = 5{\cdot}4 \text{ inches}$$

so there is close agreement between the results of the three methods viz., 5·8, 5·6 and 5·4 inches respectively.

LOAD LINES.

The Rules of the International Load Line Conference of 1930 have now been ratified, and are to be effective for a period of five years when they will be subject to revision and amendment if necessary. They apply to all countries of maritime importance. Specific rules regarding the positions of the various load lines are given for a standard ship of certain dimensions and superstructures with further modifications for vessels which depart from the standard ship in certain particulars.

Assigning Authorities.—The British authorities who assign load line marks are Lloyd's Register (L R.), British Corporation (B.C.) and the Board of Trade (B.T.). The initial letters of the assigning authority may be indicated by letters measuring about $4\frac{1}{2}$ inches by 3 inches marked alongside the disc and above the centre line.

The assignment of load lines is conditional upon the ship being structurally efficient and upon the provision of effective protection to ship and crew.

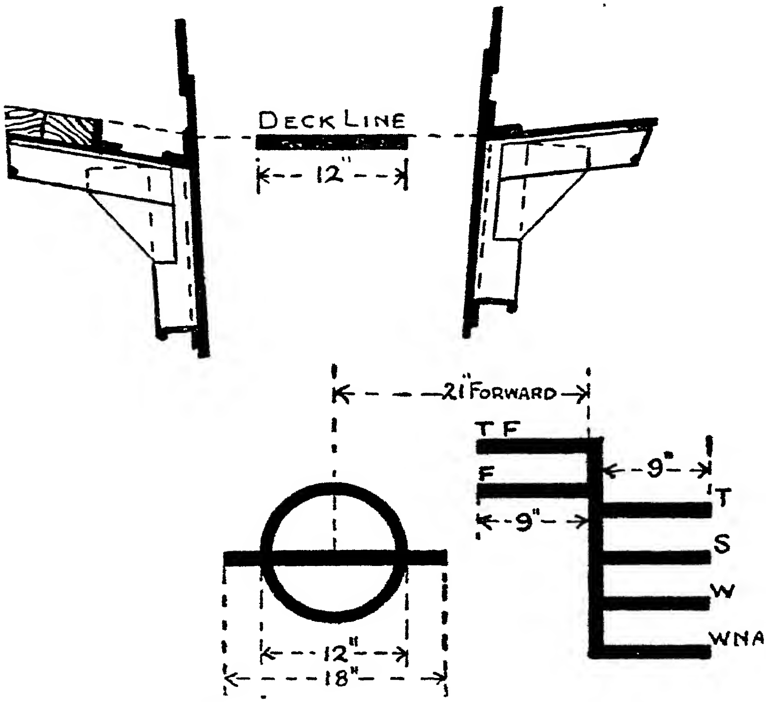


Fig. 17.—Load Lines for Steamships.

A Certificate of Approval of the marking must be obtained from the Board of Trade. This must be framed and put up in some conspicuous part of the ship.

The Penalty which an owner or master is liable to for non-compliance with these Regulations as contained in the Merchant Shipping Act, or for altering or defacing the marks, or tor overloading, shall be a fine not exceeding £100.

Details of Marking.—Figure 17 indicates the relative positions and the lengths of the lines, the diameter of the disc and the method of determining the level of the top edge of the deck line. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre punched on the sides of iron or steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose. All lines are 1 inch in breadth and the top edge of the respective lines limits the ship's immersion in different circumstances and in different seasons.

Actual Freeboard is the distance between the upper edge of the deck line and the waterline.

Statutory Freeboard is the distance between the upper edge of the deck line and the upper edges of the respective load lines.

The Summer Load Line is indicated by the upper edge of the line which passes through the centre of the disc and also by a line marked *S*.

Its position is deduced from the Load Line Tables for any particular ship.

The Winter Load Line is indicated by the upper edge of a line marked *W*. It is $\frac{1}{4}$ inch per foot of summer draught lower than S.

The Winter North Atlantic Load Line is indicated by the upper edge of a line marked *W N A* and is 2 inches lower than *W*. It applies to vessels less than 330 feet in length trading across the North Atlantic north of latitude 36° N.

The Tropical Load Line is indicated by the upper edge of a line marked *T*. It is $\frac{1}{4}$ inch per foot of summer draught higher than *S*.

The Fresh Water Load Line is indicated by the upper edge of a line marked *F*.

The difference between *S* and *F* is the allowance to be made in fresh water at the other load lines.

The Tropical Fresh Water Load Line is indicated by the upper edge of a line marked *T F*. The distance *S* to *F*=*T* to *T F*.

The difference between the minimum freeboard in fresh water of unit density and the minimum freeboard in salt water is determined by the formula: Displacement÷40×tons per inch immersion, the displacement and the tons per inch being for the summer load waterline.

Example—A vessel's displacement and tons per inch at her summer load draught are 13,007 and 47 tons respectively. Required the deduction in her freeboard when loading in fresh water.

$$\frac{\text{Displacement}}{40 \times TPI} = \frac{13007}{40 \times 47} = 7 \text{ inches}$$

Sailing Ships—Winter and tropical load lines are not marked on sailing ships The maximum load line to which sailing ships may be laden in salt water in winter and in the "Tropical Zone" is the centre of the disc.

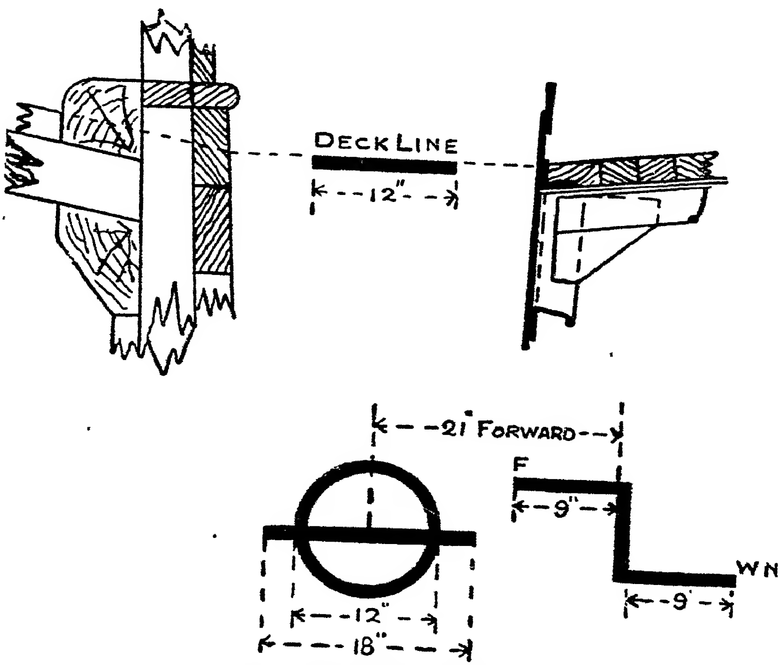


Fig. 18—Load Lines for Sailing Ships.

LOAD LINES FOR STEAMERS CARRYING TIMBER DECK CARGOES.

A Timber Load Line is a special load line to be used only when the ship is carrying a timber deck cargo in compliance with the special conditions and regulations applicable to such ships.

These additional lines are indicated in Figure 19. They are marked on the ship's side abaft the centre of the disc, the seasonal lines being preceded by the letter *L* but, otherwise, they have the same significance

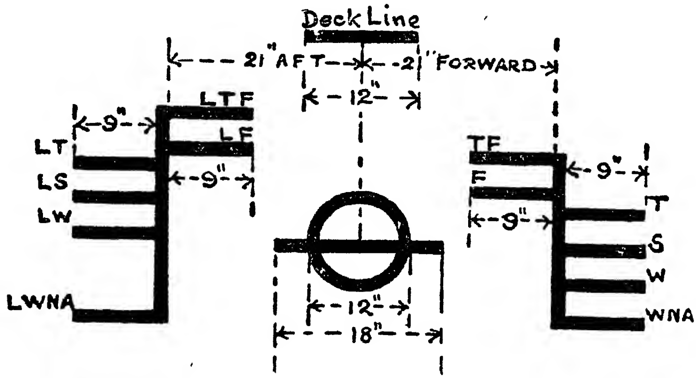


Fig. 19—Load Lines for Timber Cargoes.

as the ordinary load lines forward of the disc. It will be noted that the freeboard for a ship when timber laden is less than for other cargoes.

The freeboard for summer draught is deduced from the Timber Load Line Tables for any particular ship and this fixes the position of the *L S* mark.

L W is $\frac{1}{3}$ inch per foot of *L S* draught lower than *L S*.
L T is $\frac{1}{4}$ inch per foot of *L S* draught higher than *L S*.
L W N A is at the same level as *W N A*.

LOAD LINES FOR TANKERS.

A "tanker" includes all steamships specially constructed for the carriage of liquid cargoes in bulk, and a series of rules regulates the minimum freeboard assigned to this particular type of ship.

They have load line marks similar to other steam vessels, but the *W N A* mark is 1 inch per 100 feet in length of ship lower than the winter mark.

Full information with the modifications applicable to ships which differ in length, sheer, ratio of superstructures to length, etc., from the basic ship on which the Tables are founded is given in the "International Convention respecting Load Lines," price 3s., H.M. Stationery Office.

ZONES AND SEASONAL AREAS.

The various oceans and seas have been divided into "Summer, Winter and Tropical Zones" having definite geographical boundaries;

these demarcations, however, are rather long and complex to be recorded here. To these areas are allotted certain periods of the year which are to be regarded either as the "Summer season, the Winter season or the Tropical season," and during those periods the respective seasonal load lines on the ship's sides become the statuatory maximum load lines.

LOAD LINE SEASONS.

Areas	Tropical	Summer	Winter
North Atlantic	1 Nov -15 July	16 July-31 Oct	
North of Lat 36° N.		1 Apr-31 Oct.	1 Nov.-31 Mar.
Arabian Sea			
North of Lat 24° N.	1 Aug -20 May	21 May-31 July	
South of Lat 24° N.	1 Dec -20 May and	21 May-15 Sept. and	
South of Lat 24° N.	16 Sept -15 Oct	16 Oct.-30 Nov.	
Bay of Bengal	16 Dec.-15 Apr.	16 April-15 Dec.	
China Sea	21 Jan -30 Apr	1 May-20 Jan.	
North Pacific	1 Apr -31 Oct.	1 Nov -31 Mar.	
South Pacific	1 Apr.-30 Nov	1 Dec -31 Mar.	
Baltic		1 Apr -31 Oct.	1 Nov.-31 Mar.
Mediterranean		16 Mar -15 Dec.	16 Dec.-15 Mar.
Sea of Japan			
Lat 35° N. to 50° N.		1 Mar -30 Nov.	1 Dec.-28/29Feb.
Southern Hemisphere		16 Oct.-15 Apr.	16 Apr.-15 Oct.

The boundaries and the seasonal dates for the respective zones are published and freely circulated so that it is not likely that mariners will be expected to memorise the above particulars, but they are given here to indicate the importance and the significance of the various load lines. *See* Map.

NOTICE TO MASTERS

MERCHANT SHIPPING ACTS.

Load Line, Draught of Water and Freeboard.

Entries in Official Log Books.

Under the Load Line Regulations dated March 31, 1930, the master of any ship registered in the United Kingdom marked with a load line will be required as from the 1st October, 1930, to enter in the official log book the following particulars of draught of water and freeboard:—

Foreign-going Ships.—(1) The draught of water of the ship as shown on the scale of feet on her stem and stern post when the ship is so loaded

THE HEADINGS OF

LOAD LINE AND

Position of the Load line Disc and

The centre of the disc is placed at________feet________inches below the Maximum load line in fresh water________feet________inches above the centre of the disc.

Maximum load line in Indian summer________feet________inches above the centre of the disc,

Maximum load line in summer the centre of the disc.

Above particulars to be taken from Load line Certificate.

The maximum draught of water in summer is the draught of water of the ship as shown on the scale of feet on her stem and stern post when

DATES OF DEPARTURE FROM AND ARRIVAL AT EACH DOCK, WHARF,

Upon every occasion of the

DEPARTURES												
Date and Hour of Departure.	Dock, Wharf Place or Harbour.	Actual Draught of Water *		Actual Freeboard Amidships *			Density of Water.	Allowance.				
		Forward.	Aft.	Port.	Starboard.	Mean.		For Density of Water *	For Ashes and Rubbish.*		For Fuel to be Consumed on Stretch of Inland Water.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)		(11)	
		Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.		Ins.	Weight.	Ins.	Distance.	Ins.

that the upper edge of each line marked "S" is on the surface of the water and the ship is upright on an even keel (*i.e.*, the mean draught to the centre of the disc).

(2) The ship's actual draught of water, actual freeboard amidships and mean freeboard when the ship is ready to leave any dock, wharf, place or harbour for the purpose of proceeding to sea.

(3) The density of the water.

(4) Allowances if any for fresh water, ashes to be thrown overboard estimated amount of fuel likely to be consumed before reaching salt water.

(5) The mean draught of water and mean freeboard amidships of the ship in salt water after deducting the above allowances, if any.

(6) The date and time of recording the particulars of draught of water and freeboard on the Notice (Form L.L.14).

Home Trade and Coasting Ships.—Masters of these vessels will be required to record in the official log book the particulars stated in 1, 2, and 3 above.

Posting of Notice.

The master of a foreign-going ship is also required to put up in a conspicuous place on board the ship so as to be legible to all members of the crew, a Notice (Form L.L. 14) giving particulars of draught and freeboard of the vessel on leaving any dock, wharf, place or harbour for the purpose of proceeding to sea. The master and first mate will

AN OFFICIAL LOG.

8

)RAUGHT OF WATER.

he Lines used in connection with the Disc.

________deck line marked under the provisions of the Merchant Shipping Act, 1894.

Maximum load line in winter________feet________inches below the centre of the disc.

Maximum load line in winter, North Atlantic________feet________inches below the centre of the disc.

Maximum draught of water in summer________feet________inches.

he words which are not applicable should be deleted.

e ship is so loaded that the upper edge of each line marked "S" is on the surface of the water and the ship is upright on an even keel.

LACE OR HARBOUR with the DRAUGHT OF WATER AND FREEBOARD
hip's proceeding to Sea.

				SIGNATURES.		ARRIVALS.	
Total Allowances.	Mean Draught in salt water as calculated after making the appropriate allowances.	Mean Freeboard Amidships in salt water as calculated after making the appropriate allowances.	Date and Time of Posting the Notice (Notice L.L.14)	MASTER.	MATE.	Date and Hour of Arrival.	Dock, Wharf, Place or Harbour
(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Ins.	Ft. Ins.	Ft. Ins.					

also be required to sign the entry of these particulars. Supplemental official log books and the authorised form of Notice (Form L.L. 14) to be used as from the 1st October, 1930, will be obtainable free of charge from the Superintendents of Mercantile Marine Offices in the United Kingdom, or from British Consular Officers or Shipping Officers at ports abroad.

Penalty.—Failure to make the required entries of draught and freeboard at the proper time renders the master liable under Section 443 of the Merchant Shipping Act, 1894, to a fine not exceeding £100 for each offence.

QUESTIONS.

1. Describe the marine hydrometer, its construction and the principle of its flotation.

2. Describe in detail how you would go about getting the density of sea water when under way.

3 Distinguish between "density" and "specific gravity."

4. A hydrometer indicates 1015 when floating in water. What exactly does this mean?

5. What is meant by buoyancy and how is it made possible?

6. A caisson when filled with ballast weighs 10 tons and measures 200 cubic feet, what weight will be on the crane when the caisson is lowered into the water.

Ans.—4·286 tons.

7. What is the weight of a ship's boat and its contents if it displaces 250 cubic feet of fresh water?

Ans.—6·93 tons.

8. In what proportion does the pressure of water increase with the depth?

9. A flat plate measuring 6 ft. × 10 ft. is suspended horizontally at a depth of 20 feet, what pressure is exerted on its surface?

Ans.—76,800 lbs.

10. Will a ship filled with water sink to the bottom?

11. The sea-cock of a double bottom tank is left open, the waterline is 10 feet above the top of the tank, the area of which is 1500 square feet. What is the total upward pressure on the tank top?

Ans.—428·5 tons.

12. How are water ballast tanks tested?

13. Describe the principle of the atmospheric sounding tube in determining the depth of water.

14. If the volume of air in a tube is reduced to 2 inches on reaching the bottom, what is the corresponding depth in fathoms?

Ans.—60½ fathoms.

15. Name the Authorities who assign load lines to British ships.

16. Sketch and describe fully the International Load Lines on a ship's side.

17. What do the following letters mean, *LR*, *BC*, *BT*, *S*, *W*, *WNA*, *T*, *F*?

18. Give the lengths of the various lines and their breadth, also the diameter of the disc.

19. What special significance is attached to each of the load lines?

20. What load lines are marked on the sides of sailing vessels?

21. How could you tell on looking at a ship's side whether her marks were for ordinary cargoes or for timber deck load?

22. To which edge of the load marks is a ship submerged?

23. How could you tell how much deeper the *T S* mark may be submerged when loading in fresh water?

24. What is meant by "Zones" and "Seasonal Areas?"

25. What compulsory marks, other than load lines, are shown on a ship, and where?

26. What is the penalty for not complying with the Regulations regarding statutory marking?

27. Define the following terms (*a*) Under Deck Tonnage, (*b*) Gross Tonnage, (*c*) Net Tonnage, (*d*) Displacement Tonnage, (*e*) Deadweight Tonnage, (*f*) Freeboard, (*g*) Load Waterline.

28. What is meant by "Coefficient of Fineness"?

29. How may a hydrometer be used in conjunction with the loading of a ship?

30. A ship's draught in fresh water is 20 feet, what will her draught be in salt water?

Ans.—19 feet 6 inches.

31. The distance between the F and S marks is 7 inches, how much may the $T\ S$ mark be submerged in water of density 1007?

Ans.—5 inches.

32. Given the lengths not discoloured in the tubes of three successive soundings to be (i) 8 inches, (ii) 12 inches, (iii) 2 inches, required the respective depths.

Ans.—(i) 11 fathoms, (ii) 5·5 fathoms, (iii) 60·5 fathoms.

CHAPTER XVI.

CARGO.

THE primary purpose of a merchant ship is to carry cargo. The British Merchant Navy is comprised of approximately 11,000 vessels, of over 100 tons burden excluding fishing craft, aggregating 22 million tons burden. They convey annually millions of tons of raw material and manufactured goods between home and foreign ports. The handling of that raw material, the skill and labour of manufacturing it into desirable commodities and the transporting of the finished products to all parts of the world form the basis of the livelihood and the wealth of the British nation.

The shipowner's responsibility for the cargo carried in a ship begins when it is delivered alongside the vessel and ends when it is landed from the vessel at her destination. The officer's duty is to take all the precautions dictated by prudence and experience to protect the goods during the time they are in contact with the ship so that they may be delivered in good order and condition.

CARGO GEAR.

Cargoes are handled by stevedores employed by the shipowner. The officers supervise the work and are held responsible for the satisfactory completion of the job. The gear used depends upon the nature of the goods and consists of **Slings, Snotters, Nets, Trays, Can Hooks** and **Bull Ropes,** in addition, of course to the lifting gear of **Derricks, Falls, Winches, etc.**

Slings are made of 3-inch to 4½-inch manila rope, 5 to 8 fathoms being cut from a coil and the ends joined by a short splice. When splicing, two tucks of the whole strands should be given each way, then halve each strand and tuck again, but don't cut the ends of the strands close to the rope as the splice will draw a bit at first when the load is on.

Snotters may be either of rope or wire, 2 to 4 fathoms in length,

with an eye spliced in each end. The middle of the rope is passed under the package, one end is rove through the eye at the other end and placed on the hook of the derrick fall The weight tightens the snotter round the package.

Nets are suitable for small packages, bags, etc.

Strong Wooden Trays are used for lifting a number of small articles such as drums of paints, and oil, cases containing bottles, candles and other packages that can be lifted conveniently by one man and placed on the tray. The trays are constructed to lift a load up to 1½ tons and are slung with a four-legged bridle.

The **Bridle** is made of four legs of equal lengths of either rope or wire, one end of each leg being spliced into an iron ring, the other end into the eye of a hook, one hook for each of the eyebolts at the corners of the tray. The derrick fall is hooked on to the ring and the tray of goods hoisted.

Can Hooks are used for lifting casks but not, as a rule, when they contain liquid. The sling of the can hook may be of rope or chain. The hooks catch under the **chime** of the cask, and the heavier the weight the better they grip.

Chain Slings have a hook at one end and a big link at the other end. They are used to sling heavy coarse goods such as iron bars, sheet iron, structural and agricultural materials. The chain is passed round the material once, or twice if need be, and the end hooked round the chain. The derrick fall is hooked on to the big link and the weight tightens the turns of chain around the load.

Bull Ropes are used in the holds when goods have to be dragged from the ends or sides of cargo spaces into the square of the hatch before hoisting. One end is made fast to a pillar or some secure foundation, the other end being passed round the derrick fall then back to the pillar, around which a turn is taken, leaving the bight of the bull rope slack enough to keep the fall from rasping on the underside of the hatch coaming and to drag the sling of goods more or less horizontally to the hatchway. The end of the bull rope is then let go and the goods hoisted.

Incidentally, it may be remarked that "bull rope" is the name given by seamen to any length of rope which is used to prevent something from chafing or grinding, as, for example, a rope attached to a mooring buoy and led up through the end of an outrigger to keep the buoy from bumping against the ship's stem and bow plating.

Most ships are well provided with derricks and winches for the rapid

transfer of cargo, as the time spent in port is an unprofitable period. The **port** speed has to be averaged with the **sea** speed of the ship when reckoning up the time taken to complete a voyage. The more round voyages a ship makes in a year on a given route the more profitable will the venture be, hence the desire for quick dispatch.

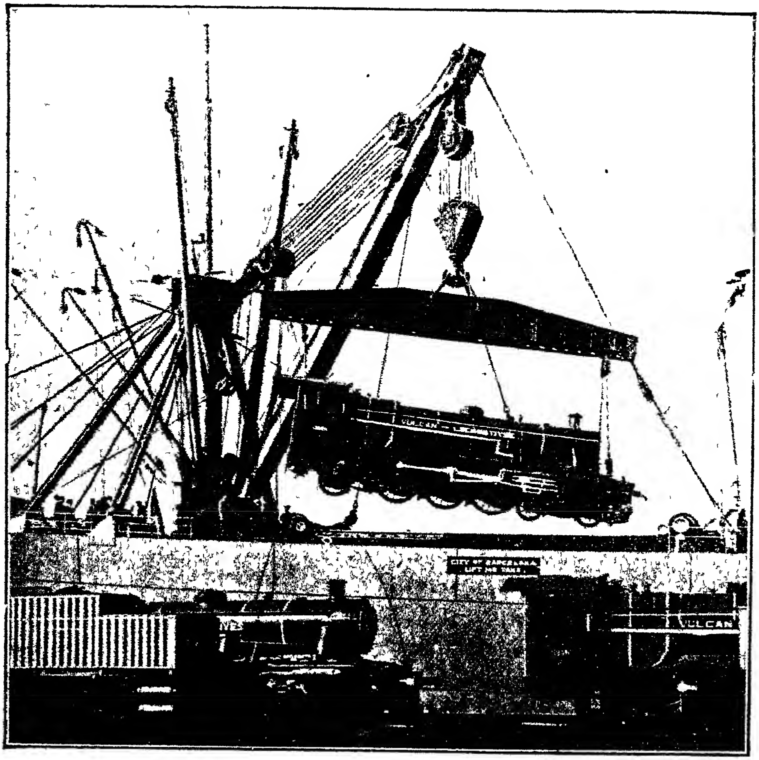


Fig. 1.—A "Jumbo" Derrick lifting 140 tons.
"Stand from Under."

The illustrations, pages 50 and 55 indicate the usual arrangement of derricks and winches. The average foreign-going cargo ship has at least two derricks and winches at each hatch capable of lifting 5 tons, and at No. 2 and No. 4 hatches an additional derrick tested to lift 20 tons, having its heel stepped on deck, the locality being strengthened by thickening the deck plating and the adjacent parts so as to

distribute the thrust of the derrick to the neighbouring members of the ship's structure

The derricks are fitted with spans. either of single chain or a wire purchase, the latter being more popular as the derrick can be easily upended to any desired angle; also with two guys consisting of wire pennants with rope purchases on their ends. The big derrick is rigged in the same way but with heavier gear and triple or quadruple lifting purchase and span. When lifting a heavy weight the mast must be stiffened with preventer backstays

The illustrations, pages 45 and 46, show a Mannesmann tube derrick being tested with a load of 42 tons on the ss. *Clan Macarthur.* A few ships employed in special trades where heavy machinery may occasionally be carried are fitted with gear to lift loads exceeding 100 tons.

The Factory and Workshops Act insists upon all chains, hooks, swivels, shackles and derricks being tested and examined periodically. When they are passed by H.M. Inspector of Factories, a Registered Certificate of Test and Examination is issued and kept on board the ship. All gangways, hatch and deck openings should be guarded, when possible, against the possibility of persons inadvertently stumbling, particularly during a temporary stoppage of cargo work. Apart from the hurt to individuals arising from an accident, it is well to remember that the Employers' Liability and Workmen's Compensation Acts are comprehensive and far reaching, and it is the duty of officers as the responsible representatives of their employers to see that all precautions are taken to ensure that everything in connection with the handling of cargo is satisfactory and reasonably safe.

The cargo gear should be overhauled at sea, when **Gins, Runners, Shackles, Guy Falls, etc.**, should be examined and refitted if required. **Goosenecks** of derricks should be lifted and greased occasionally. When the loading of a hold is completed the hatches are put on, covered with tarpaulins and battened down securely. Derricks are lowered into their crutches and lashed down. If the ship is proceeding on a long passage the gear is unrove and stowed away in its appointed place. Provision is made in some ships to stow the gear in a compartment within the coamings of the hatch; in others, where the heels of the derricks are mounted on a table, or tabernacle, built round the mast, the enclosed space is utilised as storage accommodation.

Derricks are rigged and made ready for cargo work when entering the port and, if possible, before the ship reaches her berth in readiness

for discharging. Hatches, however, should not be touched when the cargo is a valuable one until they have been surveyed, and this is usually done if heavy weather has been experienced and there is a possibility of damage to the cargo.

The Union Purchase or "married gear" is a favourite arrangement for loading and discharging. It consists of two derricks, both fixed, one guyed to plumb the hatch, the other to plumb overside. The falls from both derricks are shackled to the same cargo hook. The sling of goods in the hold is hooked on and hove up with the midship fall until it is clear of the hatch coaming The slack of the fall from the other derrick is then run in quickly and the midship fall eased off until the load is wholly borne by the overside derrick and lowered into a lighter or on to a quay. The cargo hook is then hove back again to take the next sling.

This method, for speedy work, requires two quick acting, reliable winches and operators. It is suitable for light loads of about 5 to 10 cwt. per sling, but the extra strain imposed on the falls and guys as a result of the cross pull is a disadvantage.

Swinging Derrick.—When there are no obstructions in its way a swinging derrick having a long reach is, perhaps, the speediest and most reliable arrangement for working heavy slings of bag cargo up to a ton and a half in weight, especially if it be fitted with an adjustable span so that it may be regulated to plumb the hatch and also overside. It can pick up and land the goods anywhere within the radius of its swing, thus accelerating the work of handling the goods and making up the sets for slinging.

The outboard guy, when discharging cargo, is usually led to a steam winch and the light derrick is sometimes pulled inboard by leading the guy through a block aloft and securing a heavy weight, a "dead man," on the end of it. There may be a prejudice against the "dead man" method of controlling the inward swing owing to the danger of someone getting hurt by the descending weight.

The Double Lift method is sometimes used for the rapid handling of mixed general cargo, viz., one derrick lifting off the quay and landing on deck, and another derrick picking off the deck and lowering into the hold, using skidboards where required.

More men are required per stevedore gang for the double handling, but rope whips substituted for wire falls and worked on the winch ends make for increased speed which may offset the increased labour cost.

The working of derricks is, however, the middle operation when loading or discharging There is the labour of making up the sets or slings to feed them, also the distribution of the goods when landed, either in the ship's hold when loading, or into a lighter, or on the quay, when discharging. The three operations of slinging, transporting, delivering, should be organised to time in with each other as closely as circumstances and the human element will admit.

Winches —The engine-room staff attend to the overhaul of winches, windlass, steering gear and other deck machinery. The deck staff, however, are called upon to work them and they should, at least, be able to pack the glands at the ends of the cylinders steamtight, as they may give out when working cargo and a mechanic not available. The job is a simple one.

Care should be taken before starting a winch to open the cocks in the cylinders to drain off any water that may be lodging in them. The steam should be turned on gently at first, especially if the winch has been standing idle for some time and this is particularly necessary in cold or frosty weather. When frost is severe the winches not in use are sometimes kept turning slowly out of gear to prevent the steam pipes from cooling off and freezing up.

DUNNAGE.

Most vessels have permanent dunnage or ceiling covering the tank tops consisting of 3-inch planking resting on bearers about 2 inches deep, which form an air space between the tank top and the ceiling to dry up moisture.

Portable Side Battens consisting of boards about 6 inches broad and 2 inches thick, spaced about 9 inches apart, are fitted into cleats on the side framing of the ship; the battens may be arranged horizontally or vertically and sometimes diagonally. **Stokehold Bulkheads** are usually fitted with battens and other bulkheads also. This permanent dunnage is usually sufficient for rough cargoes and for goods that are not liable to absorb moisture.

Additional Dunnage should, nevertheless, be laid at the bilges where water is likely to accumulate. also on stringers and stringer plates where moisture from condensation or otherwise may trickle down the shell plating and framework of the ship and lodge on the stringer.

Matting should always be laid on the ceiling for bale goods and bag cargoes, and if the nature of the cargo is likely to draw moisture an

additional 2 or 3 inches of dunnage should be laid on the ceiling and at the turn of the bilges.

The Dunnage Wood is of various lengths and thicknesses, and it should be kept clean and dry, as many cargoes, especially foodstuffs in bags, generate heat and absorb moisture, dirt and oil stains from dirty dunnage wood.

Regulations regarding the dunnaging, stowing and ventilating of particular cargoes are enforced at some ports, particularly for rice and grain, and the conditions of loading them must be complied with.

HOMOGENEOUS CARGOES

Coal as a homogeneous cargo ranks first in importance as it is the only mineral product the United Kingdom possesses in excess of home requirements, the normal export being about 60 million tons per annum, and, in addition, some 16 million tons are delivered at coaling stations abroad for bunkering ships. It is still the engineer's chief source of energy.

Coal is shipped from ports in the Bristol Channel, North East Coast of England, Firths of Forth and Clyde, and abroad from Newcastle (N.S.W.), Pennsylvania, (U S.A.), Natal, Calcutta and Shanghai.

This cargo is loaded usually alongside specially constructed "tips," the coal being tipped out of the railway waggon into a shute leading into the ship's hold At some ports the waggon is lifted bodily with a crane, swung over the hatchway and emptied into the hold. The discharge is usually by tubs filled in the hold, hoisted up and swung outboard on to the quay or into lighters alongside, although elevator conveyancers working on the principle of a bucket dredger are available at some ports. At other places mechanical grabs are used. The grab is lowered from the end of a crane into the hatchway, closes its "jaws" on a few tons of coal and is then hoisted up and emptied into waggons or lighters Specially constructed colliers making short voyages have been built for this particular trade, the features being large hatchways and self-trimming holds.

Surface Ventilation is essential with a coal cargo as the gas is lighter than air and must be given an opportunity of escaping upwards through the ventilators and a hatch should be left off in fine weather. Through ventilation is to be avoided as a current of air passing through the mass of coal might stimulate into activity any dormant gases into spontaneous combustion.

It is recommended that colliers and vessels carrying coal on long passages should unship the side dunnage battens and so remove this avoidable source of providing air pockets and the supply of oxygen necessary for combustion.

All kinds of coal, even anthracite, are liable to spontaneous heating and combustion, though some are more dangerous than others

All coal gives off inflammable gas when freshly worked or when freshly broken, and the gas becomes explosive when mixed with certain proportions of air

Heating of coal does not proceed from the presence of gas, but is caused by the absorption of oxygen from the air

This absorption and the accompanying development of heat is greater at high than at low temperatures, so that when once commenced it proceeds at an increasing rate if the supply of air is maintained.

Danger of over heating and spontaneous combustion increases with the length of time the coal remains in the ship, 77° Fahr. being a critical temperature.

There is no risk entailed by coal being wet when taken on board It is not in any way more dangerous to carry than coal which is perfectly dry.

When loading a cargo of coal the dunnage wood is stowed at the ends of the holds and covered up to keep it clean and clear of the coal.

The first few tons of coal are lowered into the hold, instead of being dropped from a height, and some planks laid over the ceiling in the square of the hatch. Provision is made so that when loaded the temperature of the cargo below the surface can be taken in different parts of the hold. The trimming of the cargo should also be carefully superintended and an efficient system of surface ventilation maintained.

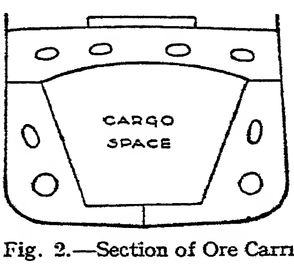


Fig. 2.—Section of Ore Carrier.

Ores.—Iron, manganese, copper and other ores are also carried in bulk, but owing to the heavy nature of such cargoes a great amount

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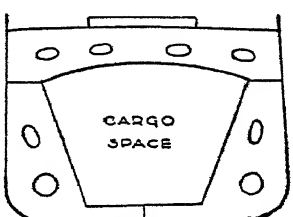


Fig 2.—Section of Ore Carrier.

Ores.—Iron, manganese, copper and other ores are also carried in bulk, but owing to the heavy nature of such cargoes a great amount

of space is left in the holds when the ship is down to her load line weight is unavoidably concentrated over a small area of the thus causing excessive strains locally. (See Fig. 9, page 430) ships are, therefore, specially strengthened and designed for this A transverse section of a special ore ship is shown in the illustı Ores are loaded and discharged as in the case of coal, according custom of the port

Grain.—The principal grain ports are Montreal, New York, adelphia, San Francisco, Vancouver and ports in the River Plate tralia and New Zealand. Rice is also classed as grain and is loa bags at ports in the Far East, the chief being Calcutta, Ra Bassein, Saigon and Bangkok.

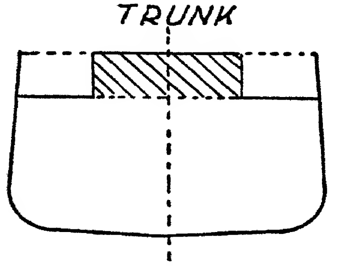


Fig. 3.—Section of a Grain Carrier.

Grain when carried in bulk is very liable to shift, the angle of of a pile of grain being about 25 degrees, so that the rolling of a s sea is capable of setting it in motion. Certain statutory regul must be complied with, under heavy penalties for evasion, by in the North American, Mediterranean and Black Sea grain t the rules being contained in a "Memorandum on Grain Cargoes" by the Board of Trade.

Special types of ships have been built for the carriage of bulk called **trunk** ships. Grain is pumped into the ship through a canvas hose until the lower hold and the trunkway are comp filled. The grain settles down from the effect of the ship's mot sea, but the grain in the narrow trunkway acts as a feeder and the hold quite full. Grain seeks into every hole and corner, so the space must be made graintight by caulking the open seams betwe planks of the ceiling or by nailing thin narrow strips of wood ov seams. When a ship, not specially built for the purpose, is requi

load a cargo of grain in bulk a temporary midship **longitudinal bulkhead** must be constructed, extending from one end of the hold to the other and from the bottom up to the deck The bulkhead is made of deal planks laid fore and aft, edge on edge, so that it forms a boarded partition dividing the hold longitudinally into two parts. Some ships have the midship pillars staggered on alternate frames so that the planks may be rove between them.

Ships engaged frequently in the bulk grain trade have steel midship longitudinal bulkheads in the lower hold.

A temporary box-shaped **feeder** must be built in the hatchway; it is also made of deals standing on their ends and reaching from the 'tween deck to the main deck hatch coamings, the whole being tomed off from the ship's side, or braced together with wire stays, and backed up with grain in bags to keep the box feeder firmly in position. The cubic capacity of a feeder should be large enough to contain from 2 to 6 per cent. of the quantity of grain in the cargo space it is designed to feed.

The grain is pumped out of the ship by elevators and stored in specially constructed granaries at those ports which specialise in its storage, so that it is not touched by hand at all.

Rice is an expensive cargo to carry as the holds have to be fitted up with an elaborate system of ventilation on the principle of a drainage scheme, so that air may pass freely throughout the whole cargo. The ventilators are box-shaped and made of two planks of wood kept about 8 inches distance apart by pieces of wood They are laid fore and aft on top of a tier of bags from bulkhead to bulkhead and also athwartships from side to side. These fore-and-aft and cross ventilators are laid horizontally on a tier of bags and spaced five bags apart, and they communicate with a series of vertical vents extending from the ceiling to the top deck. This horizontal system is laid at every third tier of bags. In addition to all this the side battens and bulkheads are covered with sticks or bamboos tied criss-cross or lattice fashion and all bare iron and dunnage is covered with rush mats.

The purpose aimed at is to secure a current of air through the cargo to carry away the carbonic acid gas given off by the rice and also to keep the hold from **sweating.** An air space is left between the top tier of bags and the underside of the deck and also round the inside of the hatch coamings. During the latter part of the rice season when the

grain is more matured the ventilation is reduced a little. The cargo is loaded under the supervision of official surveyors.

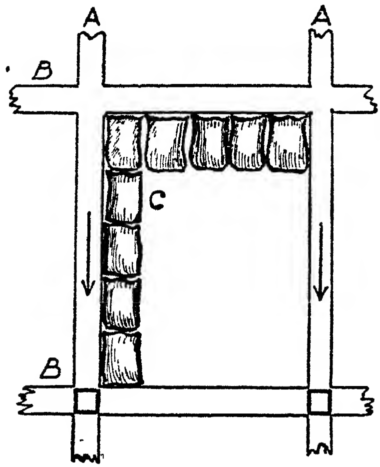


Fig 4.—Rice Ventilation.

In Figure 4, *A* indicates the fore-and-aft ventilators, *B* the athwartship ventilators, *C* the five bag spacing of ventilators. The arrows indicate the air current flowing to the vertical ventilators shown heavy.

STOWAGE OF CARGOES.

Merchant vessels exist primarily for the carriage of cargo or passengers. With respect to cargo the aim of those on board should be to prevent damage or deterioration whilst it is under their care and to deliver it, as far as possible, in as good condition and order as it was when received.

Receiving Cargo.—When about to take in any cargo, if you have not been with similar cargoes before, you should ascertain as much as you can as to its nature and what precautions are necessary with respect to it.

Evidently it is necessary to note particularly the order and condition of cargo when first received, and not to give a clean receipt for it unless its condition warrants it, otherwise the ship may be held responsible for loss or damage which it may have received prior to being shipped.

Stowing the Cargo.—In the stowage the first consideration must be given to safety, *i.e.*, the cargo must be stowed so that the ship will be stable and seaworthy, and it must be secured in such a manner that it cannot shift if the vessel encounters bad weather.

Then care must be taken to stow it so that it will not be damaged either by contact with, or proximity to, other kinds of cargo which would injuriously affect it, or from water which may find its way into the interior of the vessel, or from the sweating of ironwork, etc. Care must also be taken to prevent it being pilfered or damaged whilst being stowed.

Where cargo is being shipped for several ports, arrange it so that you can conveniently discharge it at each port in rotation in the order you visit them, so that none shall be over carried.

Deck Cargoes.—The mate's receipts and bills of lading should be signed "at shippers' risk"; this, however, does not exempt the ship from claims arising from damage due to carelessness in stowing and securing the deck cargo. Dangerous goods on deck, such as oils, acids, and chemicals, should be in packages convenient for handling in case they have to be jettisoned. Gases expand with heat and their containers should be protected from the rays of the sun. Steering gear, boats, and sounding pipes should be accessible; properly protected gangways fore and aft should be provided for the crew.

Very heavy goods to be stowed over bulkheads and the beams shored up from below. Dunnage to be laid diagonally on deck to avoid buckling of plates. Everything to be well lashed down. Deck cargo of an inflammable or corrosive nature not to be stowed on deck over a hold in which explosives are carried.

With regard to the stowage of mixed cargoes apart from ensuring that the hold is well ventilated, that the packages are properly dunnaged on a level foundation, well secured and not likely to be damaged by chafing and the heaviness of overstowed cargo, is to protect foodstuffs from being tainted by the fumes of odorous goods. Eggs and flour, for example, are easily tainted if stowed over apples, onions, copra, new sawn timber, petroleum, etc.; they should be stowed in a separate compartment if possible.

Rolls of paper are stowed on end; glass, slabs of marble and galvanised iron on their edges. Copra contains oil, it is easily ignited and should be stowed away from boiler space and from taintable foods. When loading cotton and wool in bales fire hoses should be connected, barrels of water at hatchways and buckets handy, no smoking, spark arresters on funnels and ventilators.

QUESTIONS AND ANSWERS.

1 How would you get a hold ready for cargo after discharging coal?

Sweep the sides, bulkheads and ceiling down thoroughly, send the sweepings up out of the hold.

If the weather is suitable and there is time for drying purposes, rig the hose and wash well down. If not, sprinkle damp sawdust and sweep up clean Lift the limber boards and clean out the bilges. Give them a coat of cement wash. See that the rose boxes are all clear. Replace limber boards and dunnage the hold If the cargo is to be grain in bags or anything which requires special protection, cover all bare iron with battens, burlap, or mats. Rig shifting boards if necessary.

2. If you were stationed in the hold to look after the interests of the ship during the loading of a general cargo, what would you consider it your duty to do?

I would inspect the cases or packages as they came on board, and if any appeared to be damaged, notify the chief officer at once before he gives a receipt for it. I would see that any directions printed on any package were observed whilst being stowed, such as "This side to be stowed uppermost," or "Stow away from the boilers," or that hooks were not to be used for bale goods, etc. I would particularly guard against broaching or stealing of any cargo, and see that all was properly stowed and blocked off securely Should not stow liquids above solids if it is possible to avoid doing so.

3. What would you look out for in the hold whilst discharging?

As before, I would prevent any broaching, and see that no cargo was damaged by rough or improper handling. If any cargo appeared to be damaged. I would call attention to it before disturbing it, so that, if necessary, it may be surveyed.

4. If a vessel has 'tween decks, would they require dunnaging?

Yes; sufficient to keep the cargo clear of the deck, an inch or so for cases, and a little more for bales or bags. I would lay it athwartships, so that in case of leakage the water might drain freely to the scuppers.

5. What special precautions would you take if you were going to load grain in bags for a long passage?

I would line the hold out with boards, and cover them with old sails, burlap, bagging, or mats. I would also cover up all bare iron likely

to come in contact with the cargo, such as stanchions, masts, etc., and lash good shifting boards on both sides of the stanchions amidships, so as to form a fore-and-aft bulkhead, to prevent the cargo shifting.

6 If you were going to load a cargo of raw sugar or molasses, what would you be careful about in dunnaging the hold?

To leave a free course for the drainage to run to the pump well.

7. Where would you stow bags of sheep dip, or patent manures, or any other strong smelling cargo?

Where it would not be possible for it to cause damage to other cargo by reason of the strong odour which it emits. Tea, for instance, is very liable to absorb any foreign smell; I should see therefore if any was to go in the ship that it was stowed in a different hold. The same precautions would apply to any foodstuffs such as grain, flour, etc.

8 In loading a mixed cargo, how should it be generally distributed in the hold?

The deadweight or heaviest portions of the cargo amidships in the main hold; liquids, if any, in the ends at the bottom; bales, cases, etc., in the 'tween decks or upper part of lower hold.

9. How should railway iron or tram lines be stowed?

Fore and aft solid, bases alternately up and down, this form of stowage generally being termed "locked together."

Tank tops must be protected with heavy planks laid athwartships.

Soft wood battens or old ropes or strands of an old hawser should be laid athwartships between each tier to soften the whole mass and help to bind it together.

Pillars in the hold should have wooden battens placed between them and the rails. Good heavy pieces of timber should be placed vertically at the ship's side, and the whole mass wedged up tight.

The loading should be so arranged that when all is stowed a level surface is presented right across the hold. Athwartship planks should be laid on top of the rails, and the hold filled up with other cargo solidly stowed. If the hold cannot be filled, the iron must be securely "tommed down" from the deck beams above it.

A full cargo of railway iron should be stowed locked together solid at the bottom, and diagonally or grating fashion afterwards.

Wooden battens or old ropes or strands of old hawsers should always be laid athwartships between each tier of rails.

The sides of the ship must be protected by rails locked together fore and aft and held in position by good baulks of timber placed vertically against them, the whole being wedged up tight.

The upper tiers should be laid solid fore-and-aft with good heavy planks placed athwartships on top of them, and well "tommed down" from the deck beams above them.

Good chain lashings should be used at the ends of each hold to prevent any movement or working of the iron when the ship dives into a head sea.

About a third of the weight should be carried in the 'tween decks.

Too much weight must not be placed at the extreme ends of the vessel.

It would be necessary to examine the "toms" and chain lashings frequently during the passage as they are likely to work loose. Should they do so they must, of course, be tightly wedged up again.

10. How would you stow a ground tier of casks or barrels?

I would stow each barrel fore and aft on two good beds of sufficient thickness to keep the bilge clear of the floor, and put quoins under each quarter. When stowing alongside the keelson, I would keep the bilge clear of it by putting stout pieces of wood, upright or vertical, between each quarter and the keelson. I would see that when stowed the bung was on top, and be careful to keep the tier strictly level. After stowing the wing barrels, I would fill up any space left with dunnage in order to secure the cargo.

11. How would you stow the riding tiers?

In the cantlines of the lower tier, each barrel lying on the quarters of four barrels below it.

12. How would you stow a ground tier of barrels containing dry goods, such as cement, flour, etc.?

I would dunnage the floor and then stow the barrels fore and aft, resting evenly on the dunnage. When placing them I would see that the pieces of wood forming the head were vertical, so as not to be so liable to split with the weight of the riding tiers.

Note.—Barrels containing liquids are made so that the grain of the wood in the head is in a line with the bung, so that when stowed bung up the head pieces are vertical.

13. How would you stow barrels of tar, pitch, etc.?

The sides of these barrels being straight I would not use beds, but stow them fore and aft flat on the dunnage, bung up.

14. How many hoops are fitted on a good cask?

Eight: bilge, quarter, and two chime hoops at each end. The rivets of the hoops are in line with the bung.

15 How many heights of barrels, hogsheads, puncheons and pipes are you allowed to stow?

Eight of barrels, six of hogsheads, four of puncheons, and three of pipes.

16 Why should the number be limited?

Because the lower tier, having to bear the weight of all above it, might be damaged if too many heights were stowed

17 Where and how would you stow wines and spirits?

Where they are least likely to be pilfered by crew or cargo workers. Should see that cases were all well blocked up, and that casks were carefully stowed bung up and bilge free, and well quoined and secured.

18. How would you stow bale goods of manufactured materials, etc.?

On their flats, with mark and number uppermost. Wing bales on their edges, mark and number inboard.

19. How would you stow cases of glass, slabs of marble or grindstones?

On their edges; as they would then be less likely to get broken. Large cases of plate glass are best stowed athwartships.

20. Suppose you were loading grain, and a compartment in the lower hold was to be stowed partly in bulk and partly in bags, how would you stow it?

No more than three-fourths is allowed to be in bulk. I would take that in first and level it off, then cover it over with mats and boards and stow the bags on top. Fore-and-aft boards must be not more than 4 feet apart. Athwartship ones not more than 9 inches apart. The athwartship ones must be on top of the fore-and-aft ones.

21. How would you separate different shipments of bar or rod iron?

If only two lots I would stow in different sides if possible, or otherwise by laying a piece of spunyarn across each lot before placing the next

on top of it. Knots can be tied in the spunyarn, or tallies tied on, to indicate which lot is beneath it and a corresponding note made in the cargo book.

22. What precautions must be observed when taking in gunpowder?

A magazine must previously be constructed in a suitable place in the 'tween decks, and, when receiving it on board, all fires must be put out until it is stowed and secured. Any electric wiring passing through the compartment must be disconnected. The flag *B* must be hoisted

23. Where must dangerous liquids be stowed, such as aquafortis, vitriol, etc.

In the most suitable place on deck, as in case of leakage it may be necessary to jettison all or part of it. It should be well secured and covered with tarpaulins or canvas.

24. What precautions must be observed at sea when carrying coal cargoes?

To keep the surface well ventilated by taking off some of the hatches when the weather permits, and keeping ventilators open. Also, the temperature in different parts of the hold should be tested daily and entered in the log; if it exceeds 77° Fahr. there is risk of the coal being on fire.

25. How many tarpaulins would you put on your hatches?

Two good ones with an additional older one on top.

26. How are they secured?

By turning the edges inwards and jamming them hard up against the hatch coamings by means of hatch bars and wooden wedges. Iron cleats are fitted to the hatch coamings for this purpose.

27. What makes a hatch coaming watertight?

It has an angle iron riveted to it and to the deck all round the hatch. This is made watertight by caulking at the time the ship is built.

28. What is the use of camber on the deck?

To give it additional strength and enable it to be quickly cleared of water.

29. How would you parbuckle a cask out of a tier?

Take the bight of a rope and pass its two parts one under each

quarter of the cask. Bring them up over the quarter of the next cask, carry them along the tier and make them fast round the quarters of another cask in the same tier, or to the ship's side. Haul away on the bight.

30. How do you sling a cask head up?

By standing the cask on the bight of the sling and forming a half hitch over the head of the cask with each part of the sling.

31. What arrangement or disposition of the cargo has a tendency to make a vessel "**stiff**"; and also to make a vessel "**tender**"?

Stowing all the heaviest weights in the bottom, and keeping as much cargo as possible in the lower hold, will have the effect of making a vessel "stiff." By raising the weights, and putting more cargo in the 'tween decks, she will be made more "tender."

Deck cargo tends to make a ship very tender or unstable.

32. What difference then should be made between the stowage of a cargo in a "**stiff**" **vessel** and the stowage of a similar cargo in a "**tender**" **vessel**?

The "stiff" vessel should have the heavier parts of the cargo raised more than the "tender" vessel; also when there are 'tween decks a greater proportion of the cargo should be stowed there.

33. What will be the result of **winging out weights**, *i.e.*, of stowing heavy kinds of cargo in the wings?

It tends to make the vessel steadier in a seaway, and she will roll less quickly.

34. What will be the result (i) if heavy weights are stowed at the ends of a vessel; (ii) if the heavy weights are concentrated towards the middle?

In the first case the ship will be liable to pitch heavily, and ship heavy seas at the bow or stern; she will also be subjected to severe straining in a seaway. In the second case the bow and stern will rise more easily to the force of the sea, and she will not be so liable to ship seas over the bow and stern.* Too much weight in the middle would also strain the vessel severely in a seaway.

A vessel that is very full at the bow and stern should have more cargo towards the ends than a vessel fine at the bow and stern.

* Weights at the end have also a lateral effect in making the ship slower in answering the helm.

35. What is meant by a homogeneous cargo?

A cargo which is all of one kind, such as a complete cargo of grain, coal, etc.

36. What are the mate's duties generally, in relation to the taking in or discharging of cargo?

The mate usually gives the receipts for cargo when it is received on board, and it is important that these should correctly specify the quantity and condition. He should see that a correct account or tally of the cargo is taken on the ship's behalf, and that its apparent order and condition when received is duly noted. He should also see that any instructions of the master relative to the stowing of the cargo are duly carried out, and that when the cargo is a miscellaneous one a record of the position which each part of the cargo occupies in the hold is kept in the cargo book.

In the case of a dispute arising with respect to the tally, and it is not possible to rectify it at the time, a note explaining the circumstances should be made on the receipt.

37. Should cargo come on board in a bad or damaged condition, what would you do?

Point the matter out to the shipper's representatives so that if possible they may have it put right. Otherwise, give a receipt for it in accordance with the facts. If not satisfied I should refuse to accept it.

38. You have nearly finished loading. Your ship has a list. How can you tell whether she is down to her marks or not?

Drop a plumb bob over each side of the ship and measure the distance between the upper edge of the deck line and the surface of the water. Find the mean of these two measurements which will be your freeboard at the time. Compare this with the freeboard certificate.

39. How would you stow a heavy mineral cargo, such as manganese ore?

Except in a ship specially designed for the trade, such as a "side tank" or "wing tank" vessel, I should carry about one-third of it in the 'tween decks to moderate the stability.

Should not have too much weight in the ends of the ship, number one hatch being trimmed aft, and the after hatch trimmed forward.

In the other hatches the ore is generally left higher amidships than in the wings. The slope must be a reasonable one on account of the possibility of shifting if it was heaped up too much.

SPECIAL CARGOES

The Board of Trade issue "Regulations relating to the Carriage of Dangerous Goods and Explosives" and also of "Grain." Special cargoes such as oil in barrels, cotton, grain, rice, deck loads, etc., are loaded at various ports abroad under certain statutory conditions agreed to by boards of underwriters, shippers and shipowners. We shall indicate briefly some of the more outstanding of those regulations.

STOWAGE OF EXPLOSIVES AND OTHER DANGEROUS GOODS

By the Merchant Shipping Act every person who sends any dangerous goods on board any vessel is required, under a heavy penalty, to mark distinctly and fully on the outside of the package containing the same the nature of the goods Also, he is required to give a written notice to the master or owner, of the nature of the goods, together with the name and address of the sender, either at or before the time of sending the goods to be shipped.

By dangerous goods is meant **aquafortis, vitriol, naphtha, benzine, gunpowder, lucifer matches, nitro-glycerine, petroleum and other explosives or goods of a dangerous nature.**

The master or owner of a vessel may refuse to take on board any package or parcel which he suspects to contain any dangerous goods, and may require it to be opened to ascertain the fact.

If it is found that goods, which in the judgment of the master are of a dangerous nature, have been shipped without being marked as required, or without the written notice having been given, the master may cause such goods to be thrown overboard.

GENERAL PRECAUTIONS

Petroleum, paraffin, methylated spirits, naphtha, or any liquid or substance liable, under certain conditions, to give off inflammable vapour, **should not be carried on ships which have explosives on board.**

Mineral acids, ethers, compressed gases, matches, and other substances or liquids liable to spontaneous combustion, or liable to cause fire or explosion, if carried on a vessel with explosives, **should be carried on deck only,** or if below deck should be in a hold separated by a bulkhead from that containing **explosives, and kept as far away from it as possible.**

Explosives should always be separated by a bulkhead from any other dangerous articles, and the compartment where explosives are stowed

should be kept locked to prevent unauthorised persons having access thereto.

All magazines or partitioned-off spaces for explosives must be so placed that their doors open out to a hatchway.

No iron of any sort to be used in their construction, and no fastenings but copper nails.

Dynamite should be stowed in the most easily accessible part of the hold, and proper precautions should be taken to keep it dry.

Drums of liquid ammonia should be stored in a part of the ship away from, and beyond the influence of, any heat, remote from living quarters, and as deck cargo only. They should be protected from the rays of the sun, and should not be covered with a black tarpaulin.

Bi-sulphide of carbon, also known as carbon bi-sulphuret or di-sulphide of carbon, etc.—The vapour of this is easily ignited. The mere striking together of two pieces of iron in an atmosphere impregnated with it may cause ignition. It should be carried as deck cargo only, away from all living quarters, and the utmost care must be taken to protect it from the rays of the sun, or lights or sparks. Sail cloth, but not tarpaulin, is suggested as a covering. **Smoking in its vicinity should be strictly prohibited.** The cases containing the drums should be examined at least twice a day during daylight, and if any leakage is detected they should be thrown overboard immediately. Leakage may be detected by the presence of a powerful odour.

Anti-fouling composition, anti-corrosive paints.—Certain of these give off gases which, when mixed with air, are highly explosive. Care should be taken that lights are not used in any compartment of a vessel in which such goods are, or have recently been, stowed.

Petroleum spirit, benzoline, gasoline, petrol, lythene, etc., also give off inflammable gas at all times, and in vessels carrying petroleum, etc., **special precautions should be taken against the use of lights of** any kind, also against smoking whilst the hatches are off or any deck openings uncovered.

GRAIN

Bags.—Special precautions are taken with grain in bags for a long passage. The British regulations require the hold to be divided by amidship shifting boards extending from deck to deck in the lower hold and 'tween decks, and the dunnage covered with mats.

Some countries do not insist on shifting boards and others only

grain from shifting shall each be liable to a fine not exceeding £300. The owner is also liable to the same fine, unless he shows that he took all reasonable means to enforce the proper loading of the grain and the observance of the law and was not privy to the breach thereof.

The regulations regarding grain cargoes are not the same in all Colonies and countries. The authorities in different ports make somewhat different rules. These are generally approved by the Board of Trade, and vessels loading in those ports must comply with them unless they are loaded in accordance with the Eighteenth Schedule to the Merchant Shipping Act, 1894.

OIL CARGOES.

The particular dangers connected with a cargo of petroleum spirit are fire and explosion. Petroleum spirit gives off vapour freely at ordinary temperatures, and this vapour will form an explosive or inflammable mixture with air, according to the proportions in which it is present.

The bulkheads dividing the cargo holds from other spaces should be perfectly tight.

Wooden barrels should not be used for the conveyance of petroleum spirit below deck.

Special precautions should be taken against smoking and the use of fire or light of any kind while the cargo is being loaded or unloaded.

Ventilation must be carefully attended to. Half the number of ventilators should go to the bottom of the hold, the other half reaching only a short distance down below the deck. The short ventilators should be turned to windward and the long ones to leeward.

Petroleum spirit may be carried in wooden barrels or steel drums on deck provided they are so stowed as not to interfere with the navigation of the ship or to make the vessel unseaworthy.

Petroleum spirit is any liquid which is produced by distillation from petroleum shale, or coal, and flashes at a temperature of less than 73° F., such as benzoline, gasoline, petrol, naphtha, benzol, benzine, lythene, etc.

TIMBER DECK CARGOES.

The term "timber deck cargo" means a cargo of timber carried on an uncovered part of a freeboard or superstructure deck. The term does not include wood pulp or similar cargo—

The Structure of the Ship is to be of sufficient strength for the deeper

draught allowed and for the weight of the deck cargo. She must have **superstructures** consisting of a forecastle of at least standard height and at least 7 per cent of the length of the ship, and, in addition, a poop, or a raised quarter-deck with a strong steel hood or deckhouse fitted aft.

Bulwarks.—The ship must be fitted either with permanent bulwarks at least 3 feet 3 inches high, specially stiffened on the upper edge and supported by strong bulwark stays attached to the deck in the way of the beams and provided with necessary freeing ports, or with efficient rails of the same height as the above and of specially strong construction.

Deck Openings.—Openings to spaces below the freeboard deck are to be securely closed and battened down. All fittings, such as hatchway beams, fore-and afters, and covers, are to be in place Where hold ventilation is needed, the ventilators are to be efficiently protected.

Stowage.—The wells on the freeboard deck are to be filled with timber stowed as solidly as possible to at least the standard height of a bridge.

On a ship within a seasonal winter zone in winter, the height of the deck cargo above the freeboard deck is not to exceed **one-third of the extreme breadth** of the ship.

All timber deck cargo is to be compactly stowed, lashed and secured. It must not interfere in any way with the navigation and necessary work of the ship, or with the provision of a safe margin of stability at all stages of the voyage, regard being given to additions of weight, such as those due to absorption of water and to losses of weight such as those due to consumption of fuel and stores.

Protection of Crew.—Safe and satisfactory access to the quarters of the crew, to the machinery space and to all other parts used in the necessary work of the ship, is to be available at all times. Deck cargo in way of openings which give access to such parts is to be so stowed that the openings can be properly closed and secured against the admission of water. Efficient protection for the crew in the form of guard rails or life lines, spaced not more than 12 inches apart vertically, is to be provided on each side of the deck cargo to a height of at least 4 feet above the cargo. The cargo is to be made sufficiently level for gangway purposes.

Steering Arrangements.—Steering arrangements are to be effectively protected from damage by cargo, and, as far as practicable, are to be accessible. Efficient provision is to be made for steering in the event of a breakdown in the main steering arrangements.

Uprights.—Uprights when required by the nature of the timber are to be of adequate strength and may be of wood or metal; the spacing is to be suitable for the length and character of timber carried, but is not to exceed 10 feet. Strong angles or metal sockets efficiently secured to the stringer plate or equally efficient means are to be provided for securing the uprights.

Lashings.—Timber deck cargo is to be efficiently secured throughout its length by independent overall lashings spaced not more than 10 feet apart.

Eye-plates for these lashings are to be riveted to the sheer strake at intervals of not more than 10 feet, the distance from an end bulkhead of a superstructure to the first eye-plate being not more than 6 feet 6 inches. Additional eye-plates may be fitted on the stringer plate.

Overall lashings are to be in good condition and are to be not less than ⅝-inch close link chain or flexible wire rope of equivalent strength. fitted with sliphooks and stretching screws, which are to be accessible at all times. Wire rope lashings are to have a short length of long link chain to permit the length of lashings to be regulated.

When timber is in lengths less than 12 feet, the spacing of the lashings is to be reduced to suit the length of timber or other suitable provision made.

When the spacing of the lashings is 5 feet or less, the size of the lashing may be reduced, but not less than ½-inch chain or equivalent wire rope is to be used.

All fittings required for securing the lashings are to be of strength corresponding to the strength of the lashings.

On superstructure decks, uprights, where fitted, are to be about 10 feet apart and are to be secured by athwartship lashings of ample strength.

Plans showing the fittings and arrangements for stowing and securing timber deck cargoes in compliance with the foregoing conditions and regulations are to be submitted to the assigning authority.

FROZEN AND CHILLED CARGOES.

The hold insulation of modern "meat" ships usually consists of broken up cork, the pieces averaging about the size of a pea. This is tightly packed against the sides, bulkheads, deckheads, and floors or ceilings of the spaces and held there by ¾-inch boarding, the whole occupying a depth of about 9 inches. This entirely surrounds the

carrying space except for the hatches. These, however, are insulated, really being wooden boxes about 10 inches deep, cork filled. They are neat fitting when shipped, the upper ones usually being caulked with oakum to reduce air leakage. Sometimes further precaution is taken by spreading a 3-inch layer of sawdust over them, "blind" hatches being shipped overall in the usual manner. All ventilators are fitted with wooden insulated plugs which are clamped in position from inside the hold.

The illustration shows the method of insulating a refrigerating chamber showing some of the sections lifted and the brine pipes on the bulkheads.

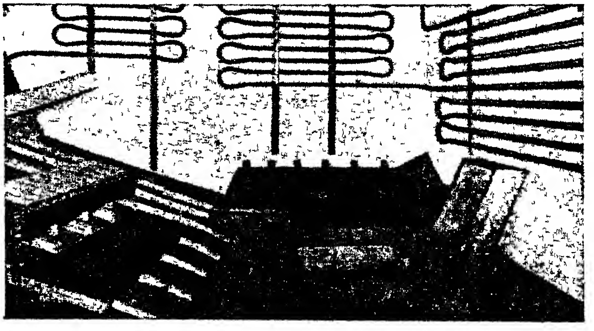


Fig. 5.

The Cooling is obtained by means of pipes of about $1\frac{1}{2}$ inches diameter through which is circulated brine of a density of about 1047 ounces at a delivered temperature of about 10° F. These pipes are secured to the wooden sides, bulkheads, and deckheads of the holds, more piping being fitted in the upper than in the lower portion of the spaces (hold or deck). 3-inch square battens are nailed athwartships on the floors, being spaced about 14 inches, and 2-inch square battens are nailed vertically to the sides and bulkheads. These battens prevent the meat from being stowed closely against the boarding and consequently losing the air circulation. All pillars, ladders, etc., are lagged with rope. When the hold is loaded, the temperature is ascertained by means of thermometers which are lowered through pipes from the weather deck.

The Preparation of the Hold for meat is important. The pipes and sides of the ship, which are varnished, are washed down with a disin-

fecting fluid (carbolecene is frequently used). The floors are washed clean, scrubbed if necessary and then whitewashed When this is dry the ventilator plugs and hatches are shipped and "cooling down" commences. If time permits, cooling down is commenced at least 48 hours before loading, so as to thoroughly bring down the temperature of all metal work Trouble is frequently experienced from sweating, and burlap is usually employed to keep the meat off the hatch coamings, etc.

The holds are generally brought down to about 10° F. when "cooling down" so as to keep a good hold on the job whilst actually loading. Frequently while loading in hot weather the temperature rises to 25° F., and occasionally so high that work has to be suspended and the holds closed until a lower temperature is regained.

Sometimes in warm damp weather the pipes become heavily coated with snow; when this occurs it has to be swept off, as snow partially insulates the pipes and reduces their efficiency. When this procedure is resorted to, care must be taken to prevent the snow from dropping in large quantities on the meat as it is liable to knit the carcases together so securely that considerable force—even wire runners—has to be employed to break them out.

At all times great care must be observed regarding cleanliness. Uncovered boots must not be permitted in the holds, and canvas "savealls" must be placed over the meat used for a landing in the square of the hatch. The loading being finished, additional pipes called "grids" are fitted in the hatchways and coupled up to the brine circulation system. This done, the insulated hatches are shipped and caulked.

For frozen produce such as mutton, lamb, beef, pork, butter, etc., a temperature of about 15° F. is maintained throughout the passage.

When Receiving Cargo, "soft" meat should not be accepted as a few soft carcases may easily rot and contaminate hundreds of others. If carcases come in soft they may sometimes be traced to the tops of railway trucks which have been delayed in transit between the freezing works and the ship Bulkheads separating insulated holds from those which are not insulated generally sweat considerably on the non-insulated side, and the cargo should be kept well clear of them.

Chilled Meat is carried in ships which have their holds insulated in a manner similar to those employed in carrying frozen meat. It is hung from the deckheads and carried at a temperature of about 29° F.

Chilled meat is being successfully carried in large quantities from the

River Plate, but on the longer voyage from the Colonies the trade is yet an experimental one.

The cross section through a ship shows the arrangement of refrigerating plant on the CO_2 system adapted for carrying mixed cargo, such as frozen or chilled meat in the holds and fruit or dairy produce in the 'tween decks. The holds are cooled by brine pipes and the 'tween decks by air circulation, the air being cooled through being circulated by a fan over a nest of brine pipes. Arrangements are usually made in the air trunks for replacing the air in these chambers by fresh air when required. See also pages 607-609.

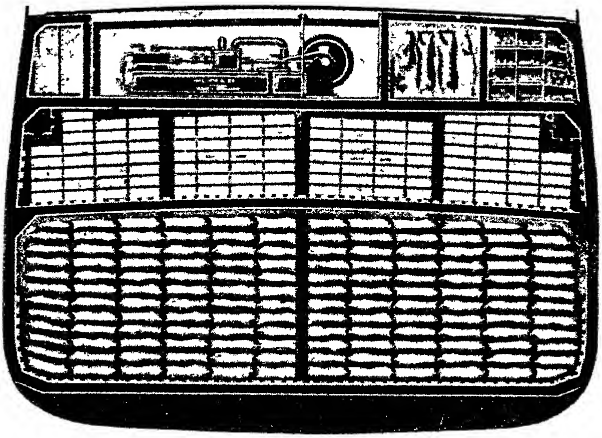


Fig. 6.

Carriage of Fruit.—The insulation for fruit carrying is similar to that for the carriage of frozen meat, in fact fruit is often carried in "meat" ships. It is important that a good air circulation should be maintained throughout the hold and that the fruit is carried at the proper temperature.

The different kinds of fruit are carried in cases or boxes (skeleton or otherwise) of a size and design best suited to keep it in good condition. Colonial apples are generally packed in skeleton cases, choice fruits from South Africa and Australasia being shipped in small boxes. Laths or 1-inch square battens are used to separate the packages and allow the air to circulate between them. Some Colonial apple cases are designed to allow air circulation without the use of loose battens to separate them.

Apples are generally carried at a temperature of 40° F to 43° F., other fruits at different temperatures according to shipper's instructions

Large quantities of apples shipped from Canada and United States are packed in barrels.

The methods adopted for the carriage of *bananas* are quite different from those employed for the carrying of other fruit. Bananas are a cargo which present considerable difficulties during their carriage by sea as they easily either chill or ripen, and as they are shipped green and must be delivered in a particular state of advancement their transport calls for great care and constant and skilful attention.

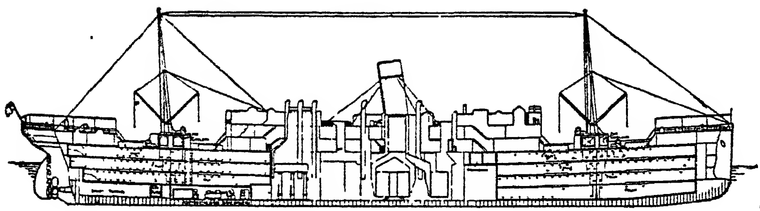


Fig. 7.—Ship fitted for Carriage of Bananas.

They are carried in specially constructed steamers which are only employed in that trade. The holds are insulated similarly to those of meat carrying steamers, but trunkways, just broad enough to permit the people in charge to walk through, separate the fruit from the insulation. Thermometers are fitted in these trunkways, their readings being taken and recorded at regular intervals. The holds and "decks" are subdivided into numerous compartments called "bins," each being about 20 feet square. The bananas are stowed in these bins.

To regulate the temperature in the holds, the outside air is cooled by passing it over brine pipes which are situated in special houses on the upper deck. It is then forced through the trunkways by large fans also situated in the special houses, which are termed "coolers."

In these ships the hold temperatures are reduced to about 37° F. when "cooling down," but this rises to about 70° F. during loading operations.

The loading being finished and hatches secured, the hold temperatures are gradually brought down again to about 53° F., which temperature is maintained throughout the voyage.

About 300 stems are placed in a bin stowed vertical and sometimes overstowed with one row ofstems on their sides. The upper part of Fig. 8

shows a side elevation, the small squares being peep holes, fitted with sliding shutters, for inspection of the fruit One ripe banana generates heat which sets up a "nest" or centre of ripening fruit which will quickly spread throughout the whole bin unless it is removed. The lower part of the figure shows in plan the breadth of a ship with insulated hold and bins side by side.

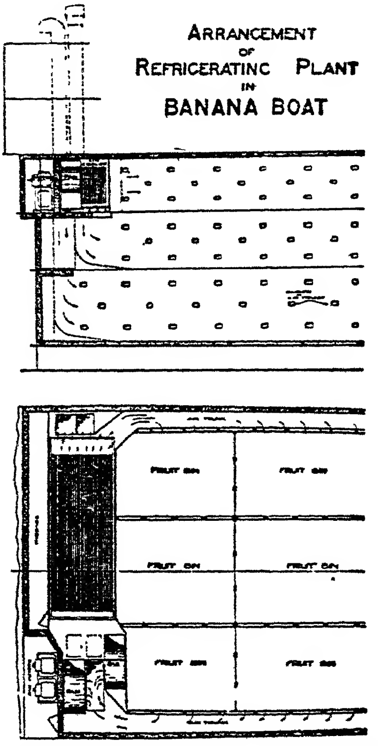


Fig 8.—Side View and Plan of Bins and Ventilating System.

The refrigerating plant circulates cooled brine through nests of pipes which reduce the temperature of the air in contact with them. The cooled air is circulated through the fruit chambers by powerful fans driven by electric motors. The air is driven into the air trunk which forms a passage-way between the ship's side and the bins, afterwards passing through the fruit chamber and returning to the circulating machine.

The conveyance of food is a specialised trade and detailed instructions are issued to their officers by the firms engaged in it regarding such cargoes, as apples, oranges, bananas, cheese, eggs, butter, beef and other commodities which are "chilled" as distinguished from meat which is kept frozen. The stowage of the goods, their supervision during transit and their handling when being loaded and discharged, are described in the private book of instructions issued by the company, and particular reference is made to the pre-cooling temperatures of the chambers at shipment, the maintenance temperatures during the passage and the temperatures desirable on opening up the chambers prior to discharging. For example, the temperature during the voyage for frozen meat is 15°; for chilled meat about 29°; for apples and butter about 33°; oranges and cheese about 40°; bananas about 53°.

A Tanker is a ship specially designed to carry liquid cargoes such as oils, molasses, and creosote in bulk, about 7,000,000 tons of various oils being imported annually into the United Kingdom. Such vessels are divided into separate oil-tight compartments by means of transverse and longitudinal bulkheads.

The compartments of an oil-carrying ship are indicated in the illustration (see p. 417) and, beginning at the bow, we note—

1. The forepeak tank forward of the collision bulkhead.
2. A hold for dry cargo with two deep water ballast tanks for trimming the ship.
3. A cofferdam extending the whole breadth of the ship and the depth of the tank. Cofferdams must be fitted at each end of the oil tanks to protect the other parts of the ship from gas. The space between the bulkheads of the cofferdam must be at least 3 feet.
4. A series of tanks numbered 1 to 11. The diagonal lines across each compartment denote that a longitudinal bulkhead is fitted. The side summer tanks are shown both in the profile and in the plan.
5. This ship has two oil pump rooms, one midway along and the other at the after end of the tanks. The pump room in the forward cargo hold is for the water ballast tanks.
6. Abaft the after pump room is the cofferdam separating the oil tanks from the engine and boiler spaces. Note the balanced rudder and the cruiser stern of this ship.
7. The plan shows the position of the hatches giving access to the expansion trunks and to the summer tanks.

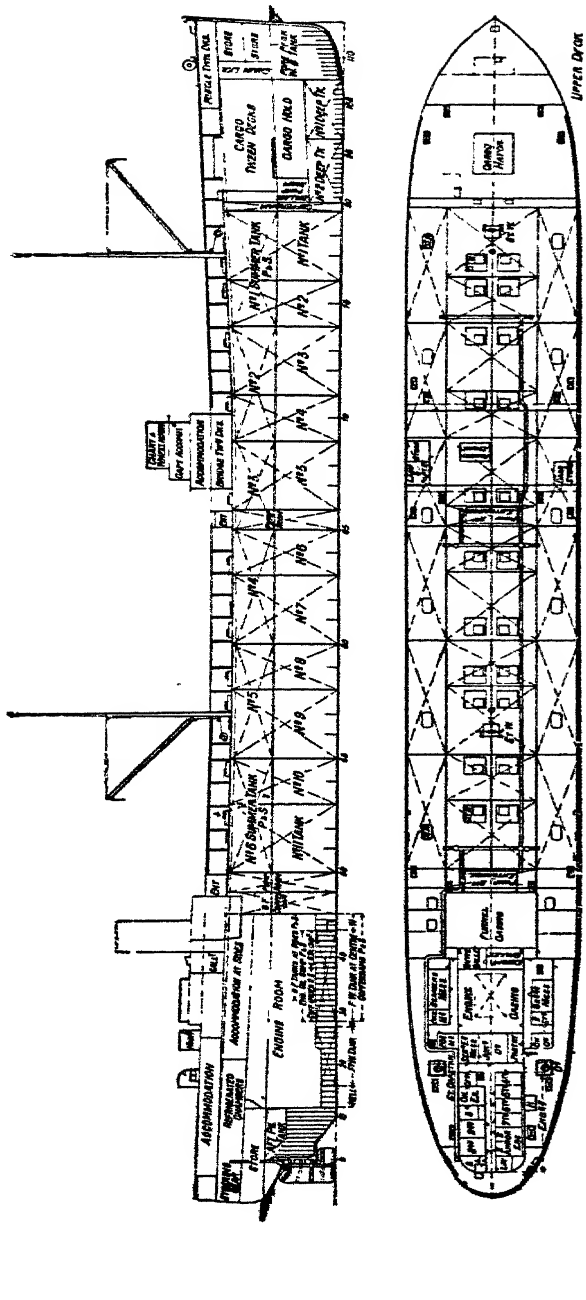


Fig. 9.—A Tanker. [From *Shipbuilding and Shipping Record*

Tanks cannot be completely filled with oil as allowance has to be made for expansion due to increase of temperature. The main tanks are kept quite full by keeping a reserve of oil in the trunk. The space above the surface of the oil in the trunk is called the "ullage," and, obviously, any change in the ullage scale indicates the change in the volume of the oil due to change of temperature. See Fig. 6, page 365. Heavy oils when heated expand about 1 per cent for every 25° of temperature.

An increase of 10 degrees in the temperature of 5000 tons of oil would increase its volume to the capacity equivalent to 20 tons weight which means that, approximately, 6400 more gallons would be pumped out at the higher temperature than was taken in at the lower temperature.

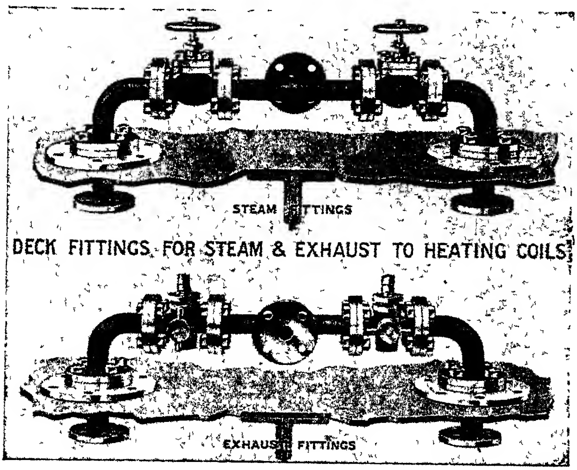


Fig. 10 —Stop Valves.

When heavy oil is too viscous, that is very thick or congealed, it cannot be pumped out, so heating pipes are either laid along the bottom of the tank or arranged in coils to raise the temperature of the cargo and reduce its viscosity. Some liquid cargoes have to be kept above a given temperature, but generally the heating up of oil is only necessary for a few days before arrival in port.

Figure 10 illustrates stop valves to admit steam to the coils in the port or starboard tanks separately or simultaneously, and the

fittings at the exhaust end of the coils as installed by Messrs. T. B. Bilton & Sons, North Shields.

The trunkway increases the stability of the vessel by reducing the surface area of the oil All liquid cargoes are unstable if the tanks are not completely filled and this cannot be done in tankers, so when the ship rolls at sea the free liquid shifts from side to side and if the quantity were excessive the ship would be liable to capsize. The middle line bulkhead being carried to the top of the trunk divides it so that the volume of free oil is comparatively small and ineffective.

The side tanks may be used for oil, dry cargo or bunkers, if required to put the ship down to her load line. When loading light spirit in the summer season the main tanks are not in themselves usually of sufficient capacity to put the ship down to her summer mark and the summer tanks are then utilised. The specific gravity of oil varies with its temperature from about ·98 in the case of heavy oils to about ·85 for petroleum.

Tube ventilators capable of being opened and closed are fitted to the tanks to admit air, or to allow the gas to escape, and they may be regulated to prevent undue evaporation from spirit cargoes, otherwise there would be considerable loss in quantity. The air pipes may be led from the tanks to a considerable height, sometimes up the masts, to carry vapour well clear of the ship when loading or discharging highly inflammable spirit, the tanks being, of course, kept closed during the operation.

When the cargo is pumped out every precaution must be taken to ensure that the empty tanks are gas free, the ship being provided with suction fans to draw off heavy gases up through piping, or with steam injectors which create a vertical current and serve the same purpose.

Oil cargoes are pumped in and out through flexible metallic hose either by pumps on board or on shore. The pumping and piping system forms a most important part of a tanker's outfit, the plant installed in modern ships being capable of pumping up to 500 tons of oil per hour.

Two main pipe lines are usually led from the several pump rooms with branch lines connecting up to each tank and fitted with control valves, so that the tanks may be worked independently or in groups, or oil may be passed from one tank to another by simply manipulating the proper valves. Needless to say, one of the first duties on joining a tanker is to study closely her pumping plan, and to understand and be

thoroughly familiar with the system, the position and operation of all valves and cocks, the connections which they make and the various combinations of tank control that are possible. Valves which control pipes in direct communication with tanks are operated by rods from deck.

Special Precautions must be taken to prevent outbreak of fire, and oil-carrying ships are well provided with fire-extinguishing apparatus, nevertheless it is the duty of responsible officers to be continually on guard and to frequently warn inexperienced and careless persons against the danger which may arise from smoking, accumulation of gas in closed spaces and tank bottoms, the creation of sparks when working with metal tools, or any frictional contact that may generate sufficient heat to ignite inflammable gas.

It is well to distinguish between the **Flash** point and the **Ignition** point of oil. The flash point is that temperature to which oil must be heated to give off vapour in sufficient quantity when mixed with air to be ignited by a flame. The ignition point is the temperature to which the oil must be raised before its surface layers will go on fire.

The flash point is an explosive temperature which is lower than the ignition temperature, the difference varying from 35° to 60° Fahrenheit in the case of fuel oils. Explosion, therefore, precedes fire. Guard against explosion. The flash point of spirit is below 75° Fahr.

CARGO PLANS.

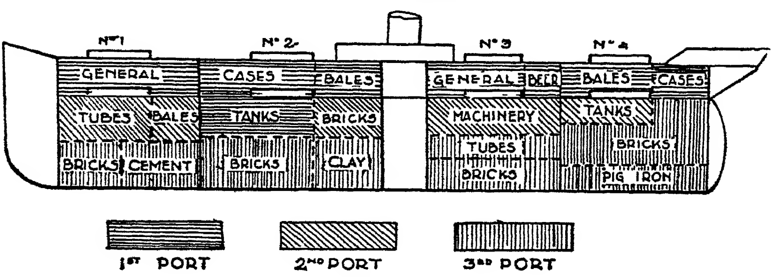


Fig. 11.

When a mixed cargo is to be loaded for several ports it is desirable to draw up in advance a rough plan of where the cargo is to be stowed, so that goods for successive ports may be readily got at in their order of discharge. An equality of distribution of the goods must also be considered so that several hatches may be worked in each port and the discharge at all hatches completed at the same time if possible. The plan in Figure 11 shows a system of identification marking for a cargo

as loaded so that the owners, stevedores and consignees may see at a glance where the cargo is stowed. Horizontal lines indicate cargo for a first port of call, diagonal lines for a second port and vertical lines for a third port. A distinctive colouring of the cargo for each port might have been used, which would probably have been more attractive but not so easily reproduced in a book.

Consideration has also to be given to the question of the ship's stability when distributing the weight of cargo in the ship, but this subject is dealt with in Chapter XVIII.

The measurement cargo capacity of a ship is known and is given in her capacity plans, and the deadweight tons to put her down to the load line marks is definitely fixed by statute. These two tonnage values, measurement and weight, automatically adjust themselves when a homogeneous cargo is loaded, for, obviously, if the ship is full no more goods can be stowed on board even if she is not down to her statutory load marks, and, conversely, if she is down to her load line marks, even if her holds are not full, no more weight can be put on board under pain of severe penalty for overloading

But when a cargo consisting of goods of different densities is to be carried it may be desired to have the holds quite full and at the same time have the ship down to her statutory load line. The determination of the proportion of quantities calls for the solution of a simultaneous equation which may be best illustrated by a worked example.

Example—A vessel of 9300 tons deadweight, loading in Calcutta, has on board 1200 tons of coal, stores and water. Her hold capacities in cubic feet are No. 1, 90270; No. 2, 108860; No. 3, 20750; No. 4, 102620; No. 5, 89370. Her cargo is to be 500 tons tea stowing at 110 cubic feet per ton, the remainder to be manganese ore in bulk at 18 cubic feet and gunny bales at 60 cubic feet per ton. Required the quantities of each to fill the ship when floating at her load line draught. Draw up a cargo plan for your calculated quantities.

Let x=quantity of ore, and y=bales

	Total deadweight			9300 tons
	less coal	1200 tons		
	,, tea	500 ,,		1700 tons
I.	Weight of ore and bales $x+y$		=	7600 tons
	Total hold capacity			411,870 cub. ft.
	less 500 tons tea at 110 cub. ft.			55,000 ,,
	Space for ore and bales		=	356,870 ,,

II.

Multiply Eq. I. by 18	$18x+60y=356{,}870$
	$18x+18y=136{,}800$
Subtract	$42y=220{,}070$
	$y=\ 5240$ tons
	$x+y=\ 7600$ "
	$x\ =\ 2360$

Ore	$=x=2360$ tons	$\times$ 18 cub. ft.	$=$ 42,480 cub. ft.
Bales	$=y=5240$ "	$\times$ 60 "	$=$314,400 "
	7600 tons		$=$356,880 cub. ft.

EXERCISES

1. A deep tank 42,280 cubic feet is filled with oil at 37·6 cubic feet per ton instead of sea water, required the difference of weight in tons.

Answer.—83·5 tons.

2. A hold of capacity 55,000 cubic feet has 100 standards of timber at 270 cubic feet per standard stowed in it. How many bales of flax could be stowed in the remaining space at 115 cubic feet per ton and 5 bales to the ton.

Answer.—243 tons, 1217 bales.

3. Convert the following cargo items into tons weight, give the total cubic capacity and total weight. (i) 300 rolls of paper, length 42 inches, diameter 36 inches, stowage factor 95 cubic feet per ton; (ii) 100 cases of pianos 6 ft. × 5 ft. × 2 ft. 6 ins., stowage factor 160 cubic feet per ton; (iii) 400 tons cased goods at 40 cubic feet per ton.

Show by a cargo plan how you would stow the goods in a small single hold ship with engines aft and two hatchways, ship full.

Answers—

Paper	7425 cub. ft.	=	78·2 tons
Pianos	7500 "		46·9 "
Cases	16,000 "		400·0 "
	30,925		525·1

4. A ship's No 4 hold measures 70 ft. × 53 ft. × 28 ft., the tunnel extends throughout its length and is 7 ft. high and 5 ft. wide.

Bales of high density cotton at 50 cubic feet to the ton are stowed level with the tunnel top. How many standard bales of cotton measuring 5 ft. × 2 ft. 6 ins. × 2 ft 6 ins. can now be stowed in the hold, and if the standard bales weigh 450 lbs., what will be the total weight of cargo in the hold?

Answer —	H D. bales	470·4 tons
	Standard bales	2493 or 500 8 tons
	Total weight	971·2 tons

5. A hold measures 32 ft. × 26 ft × 14 ft. 6 ins Dunnage is laid to an uniform depth of 6 inches.

10,000 boxes of tinfoil 14 ins. × 6 ins. × 3 ins, and 4000 drums of paint 21 ins. high and 12 ins diameter are stowed in the hold, 5 per cent. being allowed for broken stowage for the paint. Required the cubic capacity remaining in the hold, and also how many cases of goods at 25 cubic feet to the ton can now be stowed in the hold allowing 4 cases to the ton.

Answer.—4415 cubic feet, 176·6 tons, cases 706.

6. A ship's double bottom tank holds when full 335 tons sea water. Calculate how many tons of oil fuel it will contain when 95 per cent. full and specific gravity of oil 0·96. Sea water 35 cubic feet per ton, fresh water 36 cubic feet per ton.

Answer.—297 tons oil.

7. A consignment of tubes is stored on the quay in triangular heaps 3 ft. high and 4 ft. base, the tubes being 8 ft. long. If 24 of these heaps are transferred to the hold and stowed on a deck space of 40 ft. × 16 ft. to what depth will they lie?

Answer.—1 ft. 9½ ins.

8. If 5000 cases, 2 ft. × 2 ft. × 1 ft., are discharged at an intermediate port, 5 per cent. of their volume having been allowed for broken stowage, find how many tons of bagged sugar, stowage factor 50 cubic feet, will fill the space.

Answer.—420 tons sugar.

9. A single deck ship of 3500 tons deadweight has fuel and stores on board amounting to 420 tons, and also 60 tons fresh water. She has

to load esparto grass stowing at 110 cubic feet per ton and ore at 15 cubic feet per ton. How much of each can she take to fullest capacity of space and tons weight?

Hold capacities in cubic feet are—

No. 1. 51420	No. 2. 55350
No. 3. 43210	No. 4. 38883

Draw up a plan of loading and stowage of the cargo.

Answer.—1511 tons grass, 1509 tons ore

10. An oil tanker has 2 tanks each 30 ft. long, 26 ft. broad, 33 ft. deep, divided by a midship bulkhead. Crude oil stowing at 41·34 cubic feet to the ton is loaded to an ullage of 2 ft. 4 ins. in both tanks. What is the weight of the oil in both tanks?

If on heating before discharging the cargo expands 2 per cent., what will then be the ullage?

Answer.—1157 tons, 1 ft. 8½ ins. ullage.

QUESTIONS

1. When does the ship's responsibility for the good condition of cargo begin and end?

2. Describe types of slings and gear used for slinging different kinds of cargo.

3 What is a "bull" rope?

4. Describe the usual arrangement of derricks and winches in an ordinary cargo ship.

5. The ship has just completed loading; state what should now be done with regard to hatches and cargo gear preparatory to going to sea?

6. Describe the preparatory work of getting cargo gear rigged for discharging cargo. What is usually done before the hatches are taken off?

7. Describe the starting and stopping of a steam winch and the precautions necessary on occasions.

8. Distinguish between permanent, portable and temporary dunnage.

9. What is a "homogeneous" cargo?

10. What precautions are taken with regard to the loading and ventilating of coal? How can one tell if the cargo is overheating?

11. What has to be kept in view when loading heavy cargoes such as ores, and how are such cargoes stowed?

12. Why are special precautions taken with grain cargoes?

13. Describe the preparation of a hold for grain in bulk.

14 Describe the system of ventilating a cargo of rice.

15 You are responsible for receiving cargo, what precautions should be taken to safeguard the ship's interests?

16. Where should the following goods be stowed, and why :— Acids, explosives, dynamite, oil in barrels, matches, tallow?

17 When is a vessel said to be "grain" laden?

18. How is a separation made between bag and bulk grain in the same hold?

19. Describe how temporary grain feeders are constructed, why they are necessary, and what capacity they should be.

20. Why are oil cargoes in drums or barrels particularly dangerous and what safeguards are taken with them?

21 When loading a deck cargo of timber what precautions must be taken with regard to deck openings, protection of crew, steering gear, cargo lashings?

22. State what you know about the insulation of ships' holds and the carriage of frozen meat.

23 How are the following foods stowed :— Frozen mutton, chilled beef, bananas?

24. Give the temperatures at which some perishable cargoes are carried in refrigerator ships during transit.

25. What is meant by "ullage" in a tanker?

26. Why are trunks and summer tanks fitted in tankers?

27. What extraordinary precautions are exercised when carrying petroleum spirit in bulk?

28. Describe the pipe line arrangement of a tanker. Who controls the cargo valves?

29. Explain what is meant by the "flash" point and the "ignition" point of oil.

30. What parts of the hold are specially dunnaged?

31. How is a hold made grain-tight?

32. Who is made responsible for the ship complying with the Grain Laws and what penalties may be imposed, and on whom?

33. You are loading the following cargo, what form of slinging would you adopt and what quantity per sling (i) iron tubes; (ii) bales; (iii) bags of salt; (iv) cement in casks; (v) oilman's small stores; (vi) reels of paper?

CHAPTER XVII.

SHIP CONSTRUCTION.

A Ship is a Girder—A ship considered as a structural unit is a girder, a box or beam girder, composed of many small girders braced, supported and tied together so that the strength of the ship as a whole is dependent upon the effectiveness of all her members, and she is no stronger than her weakest component although some parts are more vital to the floating structure than others. The science of shipbuilding is directed to the designing and assembling of the several parts of the vessel in a practical and economical manner so that the ship may conform to the regulations laid down by the registration societies and yet be as light in weight as possible consistent with strength, rigidity and seaworthiness.

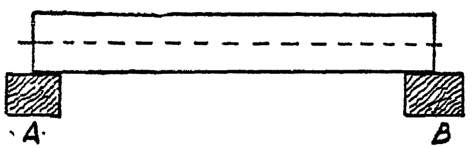


Fig. 1.—A Girder.

Longitudinal Stresses.—Figure 1 represents a narrow steel plate standing on its edge, the ends resting on supports *A* and *B*. It is a simple girder. If a heavy load *C* be suspended from its middle point,

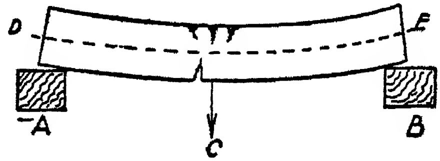


Fig. 2.

(Figure 2), the edges of the plate will be subjected to stresses, compression on its upper edge and tension on its lower edge, with a line of unchanged strength or neutral axis, *DE*, between. Should the load be excessive the

upper edge would crumple up and the lower edge break asunder. The girder would be fractured and show signs of strain.

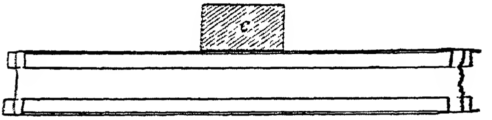


Fig 3 —Girder Strengthened with Flanges.

By stiffening the edges of the plate with angles as in Figure 3, the girder will now be able to resist distortion due to the weight *C*. The vertical plate is called the web of the girder and the edge angles its flanges. The web could now be made thinner and the arrangement gives a more efficient girder than the simple plate

A converse condition would arise when the girder, supported at its middle point *A*, is called upon to support loads *B* and *C* at each end

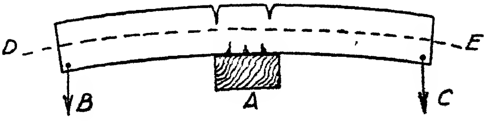


Fig. 4.

as in Figure 4. The upper edge will now be under tension and the lower edge under compression, with the neutral axis *DE* between.

A ship when afloat is subjected to similar stresses, not merely by the loads placed on board but more seriously when working in a seaway. Figure 5 represents a ship supported at each end on the crests of two waves, the weight of the hull and its contents being represented by a

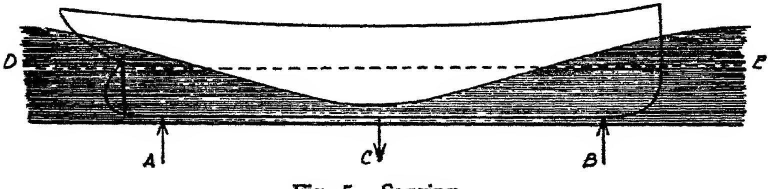


Fig. 5.—Sagging.

load at *C*. The load is, of course, not concentrated but is distributed over the length in various degrees of concentration. The upper edge of the ship is under compression, and the lower edge under tension

with a neutral area *D E* between; and if the hull of the ship were not made strong enough to resist these stresses she would bend downwards at the middle of her length This is called "sagging."

When the ship is supported amidships on the crest of a single wave as at *A* (Figure 6), with the ends *B* and *C* unsupported, the stresses are changed to tension on the upper edge and compression on the lower edge with a neutral area *D E* between, and if the hull were not made strong enough to resist these stresses she would bend upwards and suffer excessive stresses at the middle of her length. This is called "hogging" These longitudinal stresses occur alternately when a ship is among waves and the ship girder has to be specially strengthened and stiffened along the length of her strength deck by means of "sheer" strake, "stringers," etc., and along the lower edge by means of centre keel, side "keelsons" and "longitudinals" in order to make the hull strong enough to withstand all normal hogging and sagging stresses.

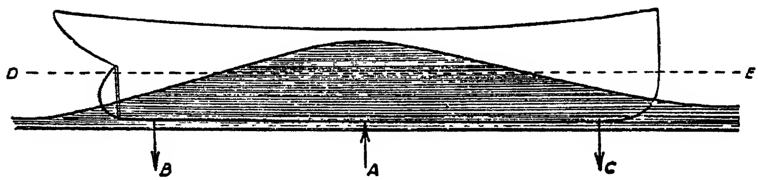


Fig. 6.—Hogging.

Transverse Stresses.—The ship is also subjected to transverse racking stresses when rolling in a seaway, the tendency of which is to cause distortion at the corners of the box-shaped girder. A simple transverse section consists of a "frame," or rib, extending the whole girth of the ship, the top ends being held firmly in position by means of a transverse beam. The beam is connected to the frame by means of a bracket called a beam "knee," which is made triangular in shape and of sufficient depth and breadth to get a good rivet connection to the beam and to the frame.

The strain of racking is likely to be more evident at the top corners than at the bottom part of a transverse section as the upper works are relatively weaker owing to deck openings and other sources of weakness in the higher parts of the structure, whereas the "floor" and "bilge" brackets make the bottom part of the section more solid and rigid.

Figure 7 shows excessive distortion. The dotted lines represent the original shape of the vessel. The frames, pillars and bottom

longitudinals have evidently been thrown out of line due to severe racking strains, and fractures would be looked for at all the top and bottom corner connections.

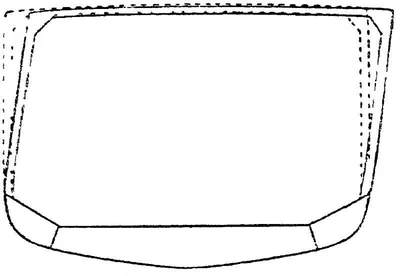


Fig 7.—Racking

Collapsing Stresses.—The water presses inwards on every submerged part of the ship in a direction perpendicular to the skin surface with a force which increases at a uniform rate of 64 lbs. per square foot for every foot depth of water. The function of the skeleton framework of the ship is to keep the shell plating to its designed shape. The plating is comparatively thin and flexible and it might readily yield inwards to the pressure of the water were it not for the frames and other stiffeners. When the ship is under way the plating has to push the

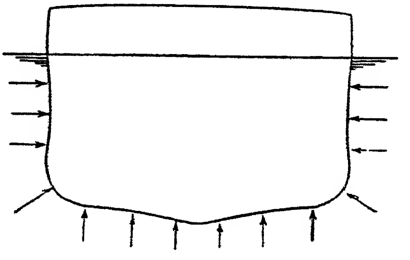


Fig 8.—Collapsing Forces.

water away at the bows, and in doing so has a tendency to vibrate, or to move out and in, these pulsations being called "panting." When the ship is pitching into a head sea excessive pounding is set up forward and aft when she rises and falls, the local stresses at the stern being aggravated by the racing of the propeller. Evidence of this is made obvious on occasions by strained plating and slack rivets. The ship girder is, therefore, specially strengthened at the ends by means of "panting" beams, thickened plating, "breasthooks," "crutches," closer spacing of

frames, stringers, deeper floors, etc., to enable the shell plating to resist its tendency to flexibility when subjected to panting stresses

The concentration of heavy weight along the middle line of the hold introduces a collapsing stress which tends to draw the two sides of the ship together. This fact was made noticeable when sailing ships loaded heavy cargoes such as nitrate in Chile, copper ore in Australia, etc. The lower layers of such cargoes were usually stowed out to the bilges and gradually narrowed in towards the middle line, leaving a space between the cargo and the ship's sides as in Figure 9. The

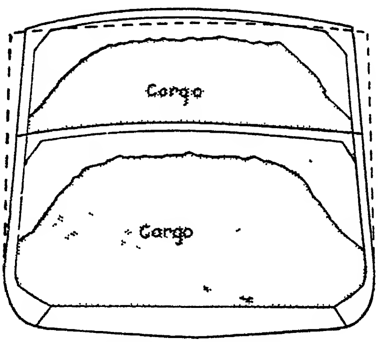


Fig. 9.—Collapsing.

rigging invariably slackened when the vessel was loaded and had to be tightened up by taking a turn or two of the box screws of each shroud and backstay. The fact was usually noted in the chief officer's log book as a reminder that the rigging had to be slackened back again before the cargo was discharged, thus allowing the hull freedom to resume its original shape.

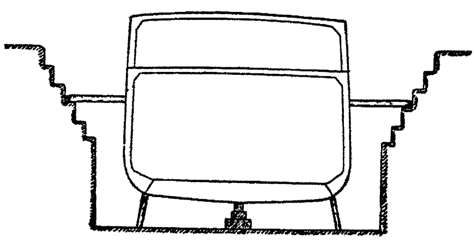


Fig. 10—Dry Dock Stresses.

The opposite effect is created when a ship is in dry dock. The weight of the hull on the keel blocks pushes the bottom of the vessel

upwards which tends to bulge the sides outwards, hence the necessity for shoring the bilges and sides to assist the hull to keep its shape.

Local Stresses.—Stresses are also set up when weights are unequally distributed in the ship as in Fig. 12, which is intended to represent a vessel divided into watertight compartments some of which are empty and others laden with cargo. Unequal vertical stresses are thus created, a downward pressure in the laden compartments and an upward pressure in the empty ones, as, of course, the ship floats at a draught which corresponds to the mean weight of the hull and its contents. Suppose it were possible to disconnect the several compartments and that each one had sufficient buoyancy within itself to float upright, then the loaded compartments *A*, *C* and *E* would come to rest at a deeper draught than the mean draught, and the lighter compartments *B* and *D* would float at a draught lighter than the mean.

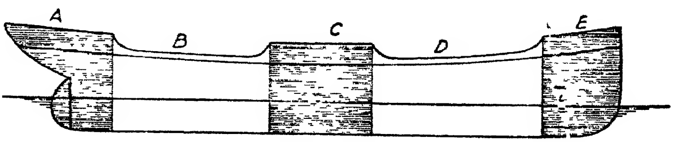


Fig. 11.

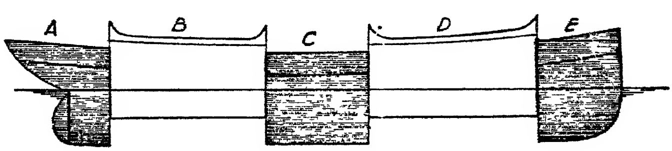


Fig. 12.—Vertical Stresses.

Localised stresses are also set up in the way of deck machinery such as windlass, cargo winches, derricks, steering gear, etc., and the structure in their vicinity is stiffened by thickening the plating, putting in additional or stronger beams, and arranging the material so that the local stress may be distributed to adjacent parts and not centralised too much at one place.

This very general and brief reference to the stresses thrown upon the ship's hull when considered as a compound girder may direct the mind of the student to the fact that the longitudinal and transverse framework of the ship is designed to enable the shell plating to keep its form and to resist any distortion and strain which might produce a leaking hull. The structure must, therefore, be made rigid enough longitudin-

ally and transversely to withstand all the normal stresses to be expected when the ship is labouring at sea with her cargo intelligently distributed and securely stowed.

The longitudinal framing consists principally of keel, stem and stern posts, keelsons, bottom longitudinals, margin plates, stringers. The transverse framing consists of floors, frames and sometimes reversed frames, tank side brackets, beams, beam knees and pillars. The shell, inner bottom and deck plating also add considerably to the strength of the ship and form the most important part of the structure, not merely because they are vital to her flotation but because the plating is the heaviest item of all the components.

We shall now discuss these several members of the ship.

A TRANSVERSE SECTION.

Figure 13 shows a few frame sections at the midship part of a sailing ship, or of any vessel fitted with open floors. It has been drawn to give us an opportunity of introducing to ourselves the names of the several components of the structure and their particular functions. First, note the "bar" keel secured to the hull by means of the "garboard" strakes; these are the two strakes next to, and on each side of, the keel. The garboard strakes are "flanged" or bent down to fit against the keel to which they are riveted, and they provide the only connection between the keel and the hull.

The Frames extend from the upper deck to the keel and, in earlier types of ships, a "reversed" frame was riveted to the frame so that the two angle bars when riveted back to back formed a very rigid rib. The reversed frame in our figure is separated from the frame angle at the turn of the bilge at the floor head, and is carried along the top edge of the "floor" to which it is riveted, whilst the frame bar is riveted to its lower edge thus stiffening very effectively both edges of the floor plate.

The "Floors" are the vertical plates extending from bilge to bilge between the inner and outer bottoms. Sailing ships had no inner bottom plating riveted to the top of the floors, just planks laid fore and aft, some of them portable so that the spaces between the floors, named the "limbers," could be cleaned and dried up. a very important operation prior to loading cargo.

Beams.—The top ends of the port and starboard frames are tied together by means of a beam, the beam being efficiently connected to

the frames by a "knee" The depth of a beam knee is at least three times the depth of the beam in order to provide an efficient riveted connection to the frame. The lower deck beams are similar to the upper deck

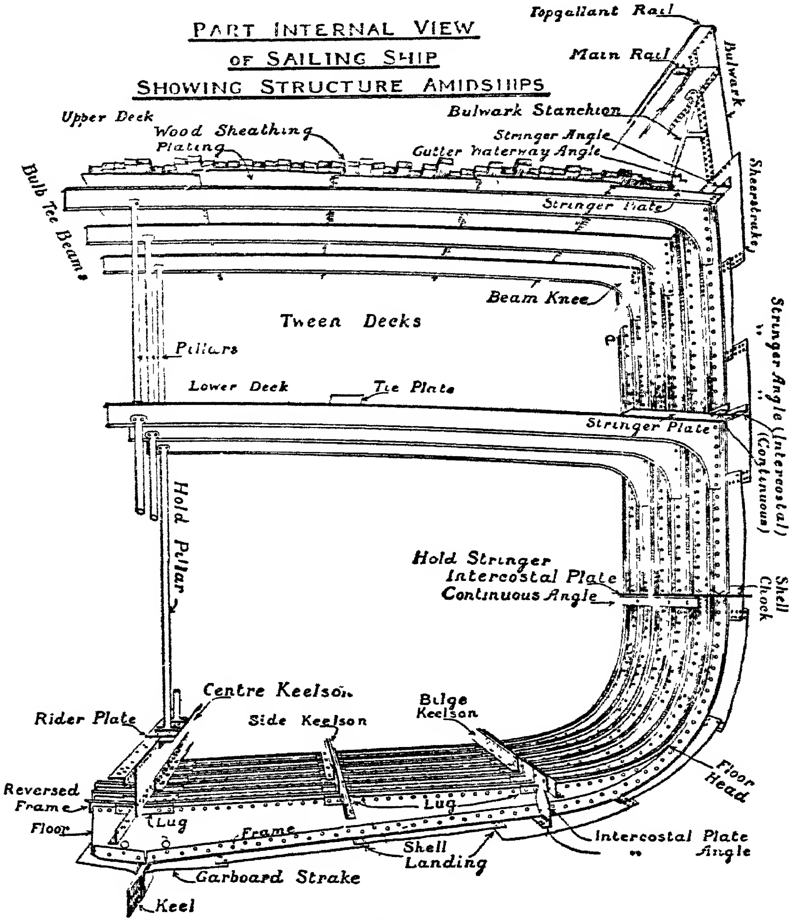


Fig. 13.

beams. The beams are slightly rounded upwards, thus forming a "camber" to shed water off the deck; the camber is usually about one-fiftieth of the breadth of the vessel, that is about one-quarter inch to the foot.

The Midship Pillars in the figure are riveted to the beam above and to the beam below, the bottom ends of the hold pillars being riveted to the top of the "centre keelson." The pillars are not merely supports to prop up the beam above but act as ties to bind together the upper and lower beams

The Transverse Sections, shaped to the form of the ship and consisting of frames and reversed frames, floor, pillar, beam and beam knees are all practically the same and spaced from 21 to 36 inches apart according to the dimensions of the ship. The frame spacing is reduced at the ends of the ship to strengthen the hull against the effect of panting and pounding when in a seaway, as the frames being much straighter at the bow and stern are less able to resist inward pressure. Refer to the plan of *Caledonian Monarch* and note that the 28-inch normal spacing of frames is reduced gradually to 24 inches from frames No. 14 aft and from frame No. 168 forward.

The Longitudinal Framing keeps the transverse sections in their correct relative positions. Note the "centre keelson," composed

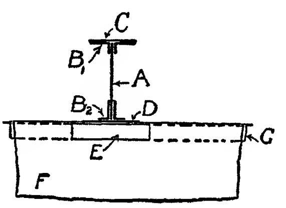


Fig. 14.—A Centre Keelson.

of a vertical plate with two angle bars on its lower edge and two on its upper edge. A flat plate, called a "rider" plate, is riveted to the horizontal flanges of the top angles, the whole combination forming a very strong centre girder or backbone for the ship. The angles on the lower edge of the centre plate are riveted to each reversed frame and to a short "lug" piece on the top edge of the floor, all as further illustrated in Figure 14.

The Centre Keelson.—*A* is the vertical plate standing on the floors. B_1 and B_2 the stiffening angles on its upper and lower edges respectively. *C* the rider plate riveted to the horizontal flanges of angles B_1. *D*, a foundation plate laid along the top of the floors and riveted to the reversed frames *G*, to the lug piece *E* and to the horizontal flange of angle B_2. *F* is the floor plate.

A Side Keelson is shown in Figure 13 consisting of two bulb angles riveted back to back with a plate fitted between them The intercostal plate is not shown on the drawing of the side keelson but it is similar to that on the bilge keelson The horizontal flanges of the two angle bars are riveted to each reversed frame and to a short lug piece.

A Bilge Keelson is also shown in the drawing. It is built up of a series of vertical plates, one into each space, the ends of each plate fitting tightly against the floors. The lower edge of this intercostal plate is riveted to the shell plating by means of a short intercostal angle. The word "intercostal" is derived from *inter* meaning between and *costa* a rib. The top edge of the intercostal extends a little above the floors and is stiffened by two angles riveted back to back, the horizontal flanges of the angles being riveted to each reversed frame and to a short lug piece as indicated in the drawing

Bilge Keels are frequently fitted on the outside of the bilge strakes for about half the vessel's length amidships to act as anti-rolling chocks They consist usually of a rolled bulb section the edge of which fits between the vertical flanges of two continuous fore and aft angles. Sometimes one angle only is used; in any case the section is riveted to the angle and the horizontal flange of the angle is riveted to the bilge strake. Bilge keels also add longitudinal strength to the vessel.

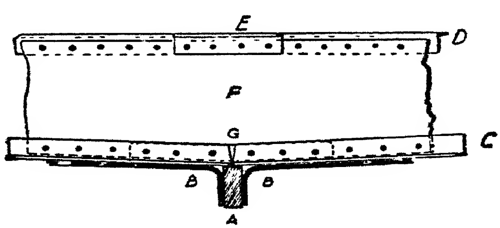
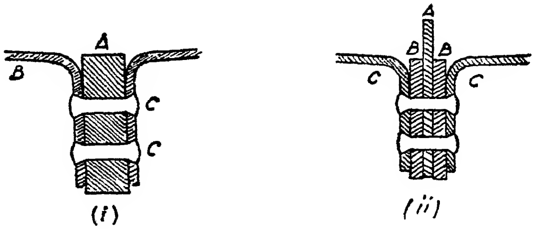


Fig. 15.—A Bar Keel.

Detail of a Bar Keel.—*A*, the bar keel, secured to the frame *C* by the garboard strakes *B*, a further riveted connection being got by heel piece *G*. *F* is the floor, *D* the reversed frame and *E* a lug piece.

In Figure 16 (i) the rivets *C* and *C* pass through the garboard strakes *B* and bar keel *A*, and (ii) represents a side bar keel, the rivets holding five thicknesses together.



Bar Keel. Fig. 16. Side Bar Keel.

Figure 17 (i) and (ii) show how a centre line keelson is attached to its neighbouring members. The centre through plate *A* is stiffened on its upper edge by the two continuous angles *B*, the horizontal flanges of which provide a rivet connection to the reversed frames and the lug pieces marked *d*. The lower edge of the keelson plate is connected to the keel plate by means of the two angles *k*, and to the floors by means

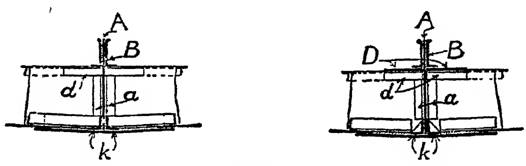


Fig. 17.

of short vertical angles marked *a*. In Figure 17 (ii) a foundation plate *D* is shown, and the angles at *k* are continuous, the frames being cut to admit of this, but in Figure 17 (i) the frames are continuous and pass through notches cut in the lower edge of the keelson plate, the angles *k*, in this case, being fitted in short lengths between the floors.

Stringers.—Above the turn of the bilge there is a "stringer," similar in construction to a keelson. These longitudinals are named stringers when they are attached to the frames, and keelsons when attached to the floors. They have similar functions, both contribute longitudinal strength, and help to stiffen the shell plating by keeping the frames and floors in their correct relative positions so that they all act together.

The hold stringer in Figure 13 is formed by a narrow plate which is notched round each frame, the outer edge of the plate touching the shell plating to which it is riveted by means of short chock angles fitted intercostally between the frames. The inner edge of the stringer plate is stiffened with a continuous angle on its under side, the vertical

flange of the angle providing the means of getting a rivet connection between the stringer plate and each reversed frame.

A Stringer Plate is fitted to the lower deck (Fig. 13), its chief purpose being to further strengthen the connection between the beams and the frames and to keep the beams square to the shell. Incidentally the stringer plate forms a narrow side platform, to walk upon as a deck has not been laid on the lower deck beams.

This, briefly, is a very general description of the framework in the type of ship illustrated. The skeleton having been built up we can easily imagine the skin or shell plating being put on, the sunk strakes first and then the raised strakes. It will be observed that the "sheer" strake, which is the strake at the upper or strength deck of this ship, extends a little above the level of the beams. This is done in order to get a watertight connection between the deck plating and the sheer strake and to offer a landing for the bulwark plate. A continuous stringer angle is riveted to the sheer strake and to the stringer plate; the stringer plate is the strake of deck plating next to the ship's side and it is invariably thicker than the other deck plates.

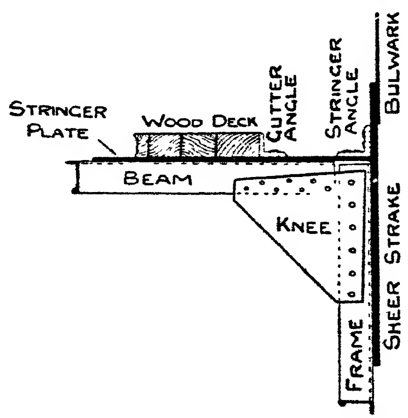


Fig. 18.—Weather Deck Stringer Plate.

When a wood deck is laid as shown in Figure 18, a "gutter" angle is riveted to the deck plating to form a strong boundary for the planking, and also to make a gutter, into which water drains from the deck before it runs out through the scupper holes.

The strakes of shell plating are not all of the same thickness, the sheer strake is the thickest, the bulwark strake the thinnest, and, curiously enough, the thickest and thinnest are riveted together in our sailing

vessel. The garboard strakes are next in thickness to the sheer strake, the thickness of the others being varied slightly. The extreme thickness of the various strakes is maintained for half the midship length of the ship and thinned off towards the ends. In shipyard practice the strakes of plating are lettered *A*, *B*, *C*, etc., from the keel upwards and the plates in each strake are numbered from aft forward; thus shell plate *C* 12 is the third strake up from the keel and the twelfth plate from the stern.

McIntyre Tank.—Figure 19 represents the formation of a "McIntyre" tank. It is really a superstructure placed on top of a ship's ordinary floors when water ballast is carried for only a portion of the length of the ship. The McIntyre system was the forerunner of the cellular double bottom method of providing water ballast space.

A is a centre plate keelson with a_1 indicating the stiffening and connecting double angles at its upper and lower edges, and a_2 the lug piece to get an extra rivet connection to the floor.

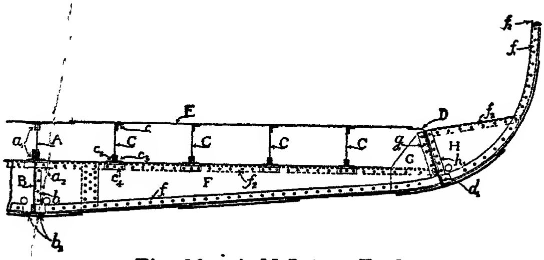


Fig. 19.—A McIntyre Tank.

B is an intercostal centre plate fitted between the floors. It is connected to the floor plate by means of a short vertical angle *b*, and its lower edge is riveted to the "flat" plate keel by means of the short fore-and-aft intercostal angle b_2.

C, *C*, *C* and *C* are longitudinal plates standing vertically on top of the floors and connected to the reversed frame by the continuous fore-and-aft angles c_2, c_3 and lug piece c_4. The top edge of the plate is stiffened with a continuous angle bar c_1, to which the tank top plating *E* is riveted. *F* indicates the floor plate.

Watertight connection at the bilge is obtained as follows:—The frame is cut at *d*, *D* indicates the "margin" plate. It extends fore and aft the whole length of the tank; its upper edge is flanged at *D* and riveted to the tank top plating, its lower edge is riveted to the bilge strake by means of a continuous fore-and-aft angle *d*.

G is a bracket plate inside the tank. It supports the margin plate and provides a rivet connection to the floor, the bracket being connected to the margin plate with the vertical angle bar g.

It will be observed from the figure that this bottom section, consisting of floors, longitudinals, angles, margin plate, the inside bracket and tank top, forms an independent unit which if buoyant enough could float as a watertight tank. Indeed this part of the ship is built first and the frame legs put on afterwards.

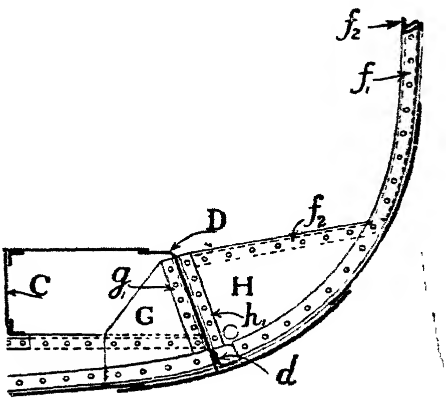


Fig 20.—Tank Side Arrangement.

The frame and reversed frames are represented by f_1 and f_2; the frame bar is cut at d, and the reversed frame is bent and riveted along the top edge of "tank side" bracket H. The bracket is connected to the margin plate by means of the vertical angle h, all as more clearly illustrated in Figure 20.

Cellular Double Bottom.—Figure 21 illustrates the transverse floor of a cellular double bottom, abbreviated to *C.D.B.* This system of construction has superseded the McIntyre tanks where water ballast is carried for practically the whole length of the ship. The *C.D.B.* is an integral part of the structure, and being well below the neutral axis of the ship adds considerably to the strength and rigidity of the vessel. It also increases her safety by providing a more substantial inner bottom to resist water pressure in the event of the outer bottom being punctured by stranding than in the case of the tank top plating of the McIntyre system. The Board of Trade measures the depth for tonnage to the inner bottom plating only, thus reducing the measured volume

as compared with a single bottomed ship and relieving the owner of certain charges which are levied on the registered cubic capacity of the ship.

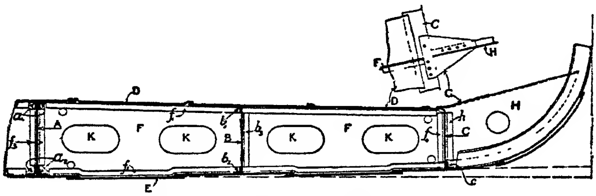


Fig. 21.—Cellular Double Bottom.

The main feature of a *C.D.B* are indicated in the figure.

A is a continuous centre line longitudinal girder, a_1 and a_2 being continuous double angles connecting its upper and lower edges to the inner bottom plating and to the flat plate keel respectively.

B is an intercostal side girder, its ends being connected to the floors by vertical angles b_3, and its top and bottom edges to the inner and outer bottom plating by the intercostal angles b_1 and b_2 respectively.

The floor plate *F* is continuous from the centre girder to the margin plate, having a stiffening angle f_1 on its top edge, which also provides the rivet connection to the inner bottom plating *D*; and the stiffening angle f_2, which is shown joggled in our drawing, on its lower edge, to provide a rivet connection to the outer bottom plating. A short vertical angle f_3 connects the inner edge of the floor to the centre girder, and f_4 connects its outer edge to the margin plate *C*.

C is the margin plate forming the side boundary of the inner bottom; its top edge is flanged and riveted to the inner bottom plating. This bottom part of the vessel is constructed first and forms a perfectly watertight unit. The frame legs are placed in position as the work progresses. The frames, in the figure, appear to be of bulb angle section which forms a rib just as efficient as the frame and reversed frame section; it saves the labour and expense of having to bend the reversed frame to exactly the same curvature as the frame and then riveting the two together; it is easier to clean and paint, thus keeping down corrosion, and the bulb stiffens the edge of the frame just as effectively as a reversed frame.

The tank side bracket *H* is riveted to the frame as indicated by the dotted line; the top edge of the bracket plate is stiffened by a flange and connected to the side of the margin plate by means of the vertical angle *h*. *C* is a continuous angle along its lower edge to connect it to

the strake of shell plating on which it rests The tank side bracket is really a continuation of the interrupted floor.

The supplementary figure shows in plan the further connection of the bracket to the cellular double bottom. *H* is the flange at the top edge of the bracket *G* is a "gusset" plate with its edge riveted to the flanged edge of the margin plate *C*, with six rivets along its centre up to the point of the gusset thus connecting it to the horizontal flange of the angle at *H*. See also page 598

Lightening holes *K* are cut in the floor plates to reduce the weight of material and to allow a free flow of water as well as access for cleaning purposes between the cells of the compartment. Small drainage holes are shown at the corners of the floors and a larger one in the tank side bracket. Water can also pass through a drainage hole at the lower corner of the bracket. It is in this space, called the bilges, where drainage water, due mostly to condensation of moisture on the sides of the ship, collects. The suction pipes leading from the various compartments to the pumps in the engine-room are usually laid in the bilges. Portable planks are secured along the top of the bilge space so that the interior is accessible for cleaning. Access to the *C D B.*, however, is only possible through manholes on the top of the inner bottom plating which, of course, are covered with a door capable of being screwed up watertight.

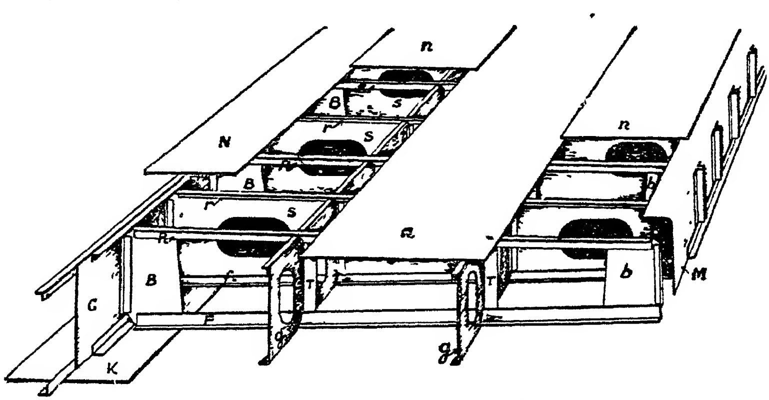


Fig 22 —Solid and Bracket Floors.

Figure 22 shows several cells of a *C.D B.* *C* is the centre plate girder with angles at its top and bottom edges riveted to the flat plate keel *K*, and centre plate of inner bottom *N*.

The number and spacing of intercostal longitudinal girders is determined by the breadth of the vessel. Two are shown at *g* and *g*, which indicates that the breadth of this vessel must have been between 58 feet and 70 feet, because one longitudinal only is necessary on each side of the centre line when the breadth is less than 58 feet. Note the lightening holes cut in these longitudinals.

Solid floors, *S*, are usually spaced two or three frames apart with open bracket floors, *B* and *b*, at the intermediate frames. Solid floors are fitted at alternate frames when the frames are 33 inches apart, and at every third frame when they are less than 33 inches apart Exception to this rule applies, however, to the engine and boiler spaces where heavy weights are concentrated and greater strength is required, and to the region extending to one-fifth of the vessel's length abaft the stem as this part is subjected to heavy pounding when labouring at sea.

F and *R* represent the frames and reversed frames of the open floors, and *B* and *b* the plate bracket at their inner and outer ends. *f* and *r* indicate the frames and reversed frames at the solid floors. *N* is the middle line strake of inner bottom plating and letters *n* indicate other out and in strakes. *M* is the margin plate with a continuous fore and aft angle on its lower edge and the short vertical angles at frame space intervals apart already riveted in position, the latter being, of course, to receive the tank side brackets.

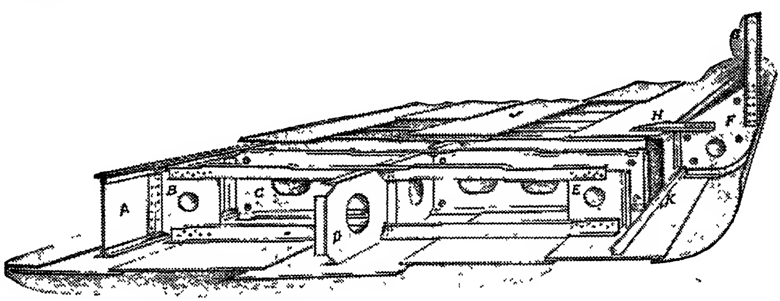


Fig. 23.—Cellular Double Bottom and Bilge Space.

In Figure 23 *A* is a centre girder. *B* a bracket. *C* a solid floor. *D*, longitudinal intercostal girder. *E*, bracket. *F*, tank side bracket. *G*, frame. *H*, gusset angle. *J*, inner bottom plating. *K*, continuous margin plate angle.

Web Frames.—A web frame is a specially deep transverse frame in the form of a built girder. They are introduced where decks have

been omitted to obtain clear holds. Ships may be built throughout on the web frame principle in order to get a clear hold for stowage of cargo by doing away with a deck and compensating for the loss of strength by means of web frames spaced about six frame spaces apart. The web frames when associated with plate stringers form a succession of strong transverse girders, the ordinary framing forming the necessary local stiffening between them.

Figure 24 (i), (ii) and (iii) represent three views of a web frame of earlier construction associated with a deep stringer; the lettering indicates the same part in each drawing. (i) is the web frame looked at from aft; (ii) is the web frame crossed by the deep stringer plate as viewed from inside the ship and looking transversely; (iii) is a plan looking downwards. The web plate is connected to the shell plating by frame angle bar *c* in (i) and (iii), and stiffened on its inner edge by double angles *b* (i) and (ii).

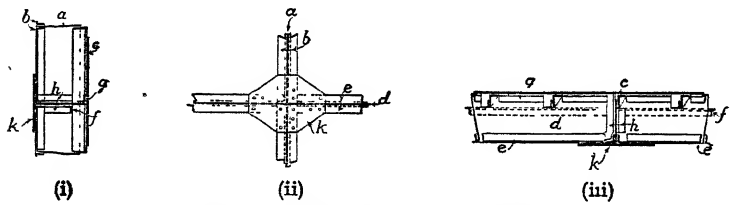


Fig 24 —Web Frame and Stringer.

The stringer plate *d* (ii) and (iii) is the same depth as the web frame plates between which it is fitted intercostally, the ends of the stringer plate being riveted to the web of the frame by short angles *h* (i) and (iii) and the edge of the stringer against the shell plating is united thereto by short chock angles *g* (i) and (iii), fitted between the ordinary frames, the plate being notched to fit round the frames as in (iii).

The inner edge of the stringer is stiffened by double angles *e* (ii) and (iii), and the junction of the web frame and stringer plate is strengthened by means of a diamond plate *k* (i), (ii) and (iii), which is riveted to the stiffening angles on the inner edges of the web frame and stringer plate. See also figure 5, page 600.

A fore-and-aft angle *f* (i) and (iii), on the under side of the stringer, gives a further rivet connection to the reversed frames.

The depth of the web frame depends on the depth of the vessel, and in cases where the stringers are deep they are supported between the web frames by brackets which may be fitted at alternate frames.

Rivets.—There are several forms of rivets named according to the form of their heads and points. In Figure 25 *A* and *B* are called "snap" head rivets, *A* having a "snap" form of point and *B* a "flush" point. Rivets *C* and *D* are "pan" heads, *C* having a snap point and *D* a "boiler" point, which, it will be observed, is more conical in shape than the flush point of rivet *B*. The boiler point is considered to be a better holding rivet than the others owing to the greater amount of hammering required to get it into shape, thus filling up the rivet hole more effectively. Snap point riveting is done with a machine, flush and boiler points are hammered up by hand. *E* is a "tap" rivet used in places where a through rivet cannot be fitted. A screw hole is tapped into the casting, the tap rivet is then screwed into position by means of the square head which, having served this purpose, is then cut off.

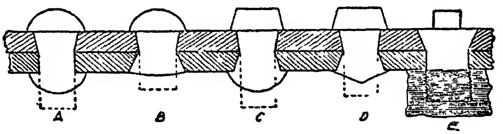


Fig. 25.—Forms of Rivets

Rivet Holes are punched in plates by means of a punching machine which makes a hole of conical form, being smaller on the side into which the punching tool first enters. Rivets are, therefore, made of slightly conical form under the head to effectively fill up the hole. Plates are punched from their "faying" surface, faying or facing being the sides of the landings which bear against each other. Thus, in Figure 25, the top plate has apparently been punched upwards and the lower plate downwards; the two plates have then been placed together, the rivets put in downwards as indicated by the dotted shape, and their points hammered up by hand into flush or boiler point; or, in the case of the snap point, with a hydraulic machine.

The Diameters of rivets vary with the thickness of the plates to be riveted. In shell plating a $\frac{3}{4}$-inch rivet is generally used for $\frac{1}{2}$-inch plates.

The Spacing of a row of rivets varies with different kinds of work. It is expressed in terms of the diameter of the rivet. The space between their centres may vary between $3\frac{1}{2}$ diameters in plating where watertight and oiltight work is wanted to 7 diameters in the case of riveting frames to shell plating.

The term "**Pitch**" is commonly used to indicate the spacing of the

rivets, measured from centre to centre. In cases where the rivets are 3½ diameters apart their pitch is said to be 3½ diameters.

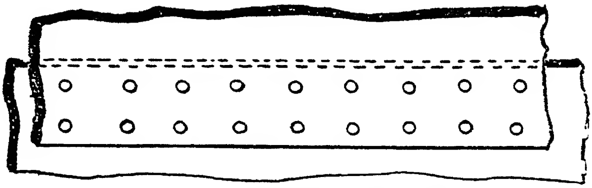


Fig. 26 —Chain Riveted Landing

The ends of plates may be connected by a "lap" joint, which is just the end of one plate overlapping the end of the other with a sufficient "landing" to take a single row of rivets, or a double or treble row as may be required. The plate landing is the name given to the breadth of

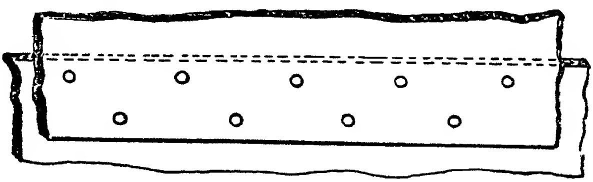


Fig 27 —Zig-Zag Riveted Landing.

the overlapping edges of two plates, which, obviously, would be regulated by the numbers of rows of rivets. The figures illustrate "chain" riveting and "zig-zag" or "reeled" riveting.

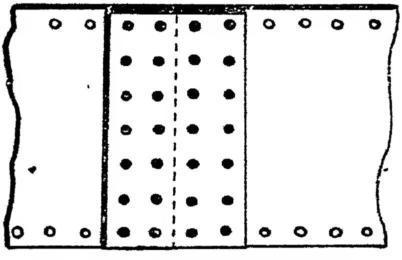


Fig 28 —Double Riveted Butt.

The ends of plates may also be joined together by means of a "butt" strap, which is a plate long enough to cover the breadth of the plate and broad enough to take the requisite number of rivets. There are

single riveted butt straps, also double and treble riveted butts as shown in Figures 28 and 29.

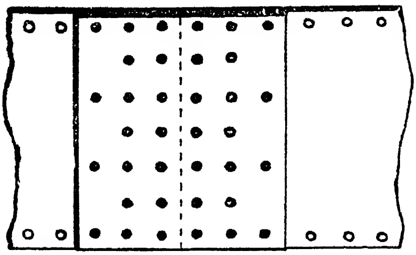


Fig. 29.—Treble Riveted Butt.

The ends of angle bars are joined by means of a "bosom" piece, or short piece of angle bar fitting closely into the angles and of sufficient

Fig. 30.—A Bosom Piece.

length to take at least three rivets in each row on each side of the joint as shown in Figure 30.

SHELL PLATING.

The system of shell plating now almost universally adopted is the "raised and sunken" strake system (Figure 31), the outer plates being sometimes "joggled" as in Figure 32. A "strake" of plating is a line of plates.

Raised and Sunken Plating.—In Figure 31, *A* is the frame, *B* is the sunk strake of shell plating resting solid against the frame, *C* is the raised strake each edge of which overlaps and rests on the edges of the adjacent sunk strakes. The overlap at *E* is called the plate "landing," and *D* is called the "sight" edge of the raised strake; the sight edge of the sunk strake would be seen from the inside of the ship. *F* indicates the position of a narrow parallel "liner" or packing piece of the same breadth as the flange of the frame; it is inserted to form a solid foundation for the raised strake to rest against. The landings of shell plating are always "chain" riveted, that is, the rivets are exactly opposite to each other as distinguished from "zig-zag" riveting. (See Figures 26 and 27.)

Joggled Plating has been introduced to save the expense and weight involved in fitting liners. Figure 32 illustrates the "double" joggled system whereby each edge of the outer strake, *C*, is bent

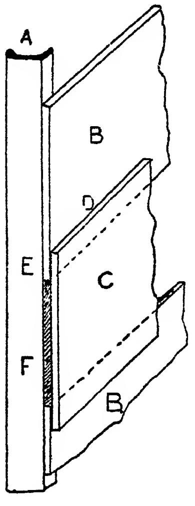


Fig. 31.—Raised and Sunken Strakes.

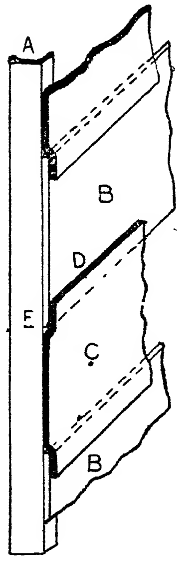


Fig. 32.—Joggled Plating.

into a joggled shape to form a landing to rest on the edges of the two adjacent strakes *B*, the joggle being deep enough to allow the intermediate part of the outer strake to lie solid against the frame.

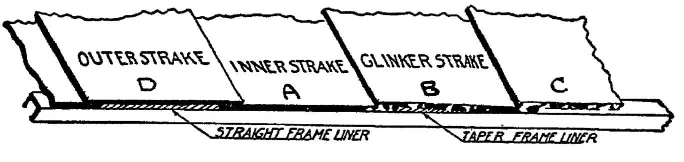


Fig. 33.—Deck Plating.

Sometimes the "clinker" system is adopted for deck plating as in Figure 33, which indicates plate *B* with one edge under the right hand

plate *C*, and the other edge on top of the left hand plate *A*. This necessitates the fitting of a "tapered" liner to fill the triangular space between the flange of the beam and the under side of plate *B*. The sight edges in this system all face the one way, and it has an advantage over the raised and sunken strakes for deck plating, as water drains readily to the scuppers as there is no sunken strake for it to lodge in.

The raised and sunken, or outer and inner, system of plating with a parallel liner below the raised strake *D* is also shown.

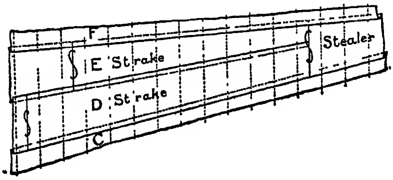


Fig. 34.—A Stealer.

A Stealer strake is introduced in the shell and deck platings towards the ends of the vessel when, owing to the reduced breadth of the plating, two strakes may conveniently be merged into one, the single strake being called a stealer, as each time it is fitted the number of strakes is reduced by one.

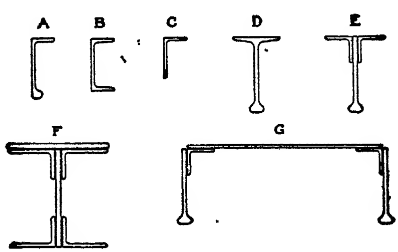


Fig. 35.—Angle and Beam Sections.

Figure 35 illustrates the rolled sections most commonly used in ship construction. *A*, *B*, *C* and *D* are rolled sections, that is to say, they are made in one piece; *E*, *F*, and *G* are built sections.

A is a bulb angle used for frames and beams; *B* is a channel section bar; *C* is a light section used as stiffeners on bulkheads, etc.;

bulb section used for beams; *E* is a built beam section introduced when a wood deck is laid over the beams, or wherever an extra strong beam is required; *F* is a heavy section introduced where great strength is required, a centre keelson, for example, and in the way of engine and

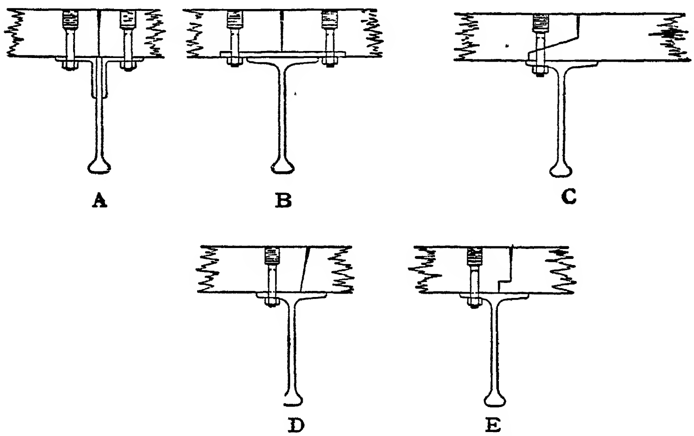


Fig. 36 —Wood Deck Butts.

boiler spaces; *G* is a semi-box beam formed by riveting a plate to two adjacent beams, thus binding them together and merging both beams into a single girder. See also page 597.

Planking.—Figure 36 illustrates beam sections showing also how the ends of deck planks are butted and bolted to the beams. A hole is bored through the plank to take a galvanised screw bolt which passes through a hole in the flange of the beam and is screwed up by means of a nut on the underside of the beam. The head of the bolt is sunk into the plank with a thread of oakum round its neck, well coated with white lead and screwed up by a nut on the underside of the beam. A "dowel" of wood, also coated with white lead, fills up the enlarged hole over the top of bolt and the planking is then planed off smooth.

It will be noticed that the planks fit closely at the lower edge and are slightly apart at the top edge. This is purposely done so that the oakum may be driven tightly into the wedge-shaped butts and seams without being forced right through. The seams and butts of deck planking are "payed," that is, filled with pitch or marine glue. In the figure, *A* is a built beam; *B* is a rolled section with a plate resting on it so that the under side of the planking has to be scored out to fit over the

plate; and *C*, *D* and *E* are different forms of butts requiring one bolt only.

Beam Knees.—There are several forms of beam knees as indicated in Figure 37, *A*, *B*, *C* and *D*.

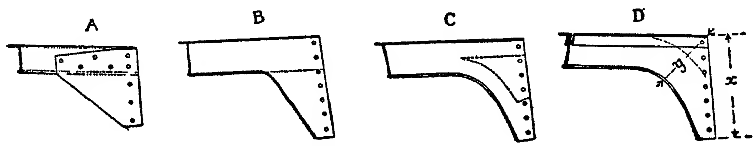


Fig. 37 —Beam Knees.

A is a "bracket" knee, the simplest and easiest type to make. It is just a plate cut to the triangular shape as shown and riveted to the beam and to the frame.

B is a "slabbed" knee. The bulb on the bottom edge of the beam is chipped off along the dotted line and a piece of plain or bulb plate welded to the beam and cut to a shape to get the desired depth of knee for a seven rivet connection to the frame as shown.

C is called a "split" knee. The end of the beam is cut inwards, or split, along the horizontal dotted line, the lower part is bent downwards to the shape required and the open space filled up by welding on a piece of plating.

D is a "turned" knee. The end of the beam is turned down as shown by the dotted curved line and a piece welded in to square off the upper corner. The depth of a beam knee, as indicated by *x*, is at least three times the depth of the beam and is regulated, together with the distance across the throat at *y*, according to the size of the ship and as set forth in Lloyd's Rules.

Where cargoes such as chilled beef are suspended from the beams of decks, which may, at the same time, be loaded with cargo above, the strength of the beams of such cargo decks is increased and also the scantlings of pillars.

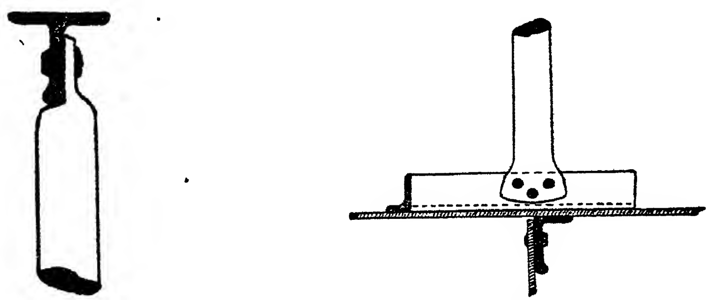
Pillars, in supporting the deck beams, relieve the sides of the vessel and the beam knees of considerable stress, and by shortening the length of the unsupported span of the beam the introduction of a pillar leads to a reduction in the size of the beam. In addition, pillars serve to tie the bottom and top of the ship together and assist to prevent deformation.

Pillars may be constructed of solid round bars, tubes, channel bars riveted back to back, four angle bars riveted together, or of various built up sections.

Their size depends on whether they are closely or widely spaced, their height and the weight to be carried. Closely spaced pillars are an advantage structurally but are very much in the way when stowing

Head Heel

Fig. 38 —Pillars



Head Heel

Fig. 39.—Pillars.

cargo, so the modern tendency is to keep cargo spaces as clear of pillars as possible in order to avoid broken stowage and loss of space. Centre line pillars are very useful, however, when erecting midship longitudinal shifting boards for grain cargoes, some ships are fitted with portable pillars.

The Figures 38 and 39 illustrate methods of securing the heads and heels of pillars.

Figure 40 illustrates a very clear cargo hold of a vessel having four massive tubular pillars, one at each corner of the hatchway. The pillars are associated with a strong overhead longitudinal girder which distributes the local supporting power of the pillars to the neighbouring parts of the vessel.

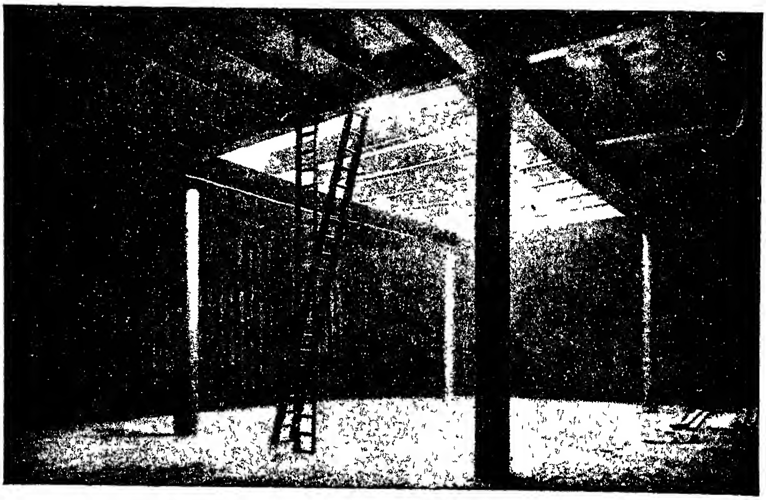
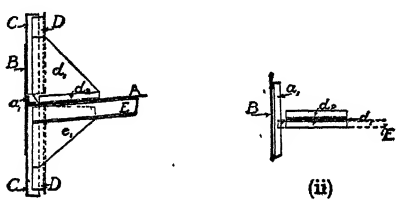


Fig. 40.—The Hold of an "Isherwood" Ship.

Watertight Flats.—It is necessary to get watertight work where the frames pass up through a side stringer plate of a watertight deck. The most common method is to cut the frame at the under side of the watertight flat so that the stringer plate resting on the beams may be



(i) Fig. 41.—Watertight Flat.

fitted close against the shell plating and be connected thereto by means of a continuous fore-and-aft angle bar. The lower end of the next section of frame bar is bracketed to the top side of the stringer plate.

In Figure 41 (*i*), A is the stringer plate lying on beam E, with its connection to the shell strake B by means of the fore-and-aft angle bar a_1. The frame C and the reversed frame D are cut at the beam and continued again above the deck as shown. The bracket d_1 is riveted to the frame and connected to the stringer plate by means of the short double angles d_2. The strake B, the continuous fore-and-aft angle a_1, and the double angles d_2 are shown in plan looking down on beam E shown dotted in figure (*ii*). See also figure 6, page 601.

Sometimes the frame is continued in order to maintain continuity of strength and rigidity. The edge of the stringer plate in this case is notched out in the way of each frame to allow the plate to bear against the shell plating. The angle bar connecting the edge of the stringer

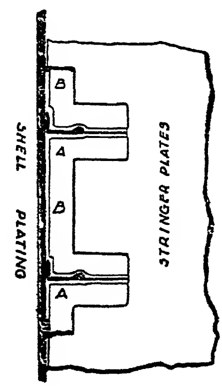


Fig. 42.—Watertight Flat, Continuous Frames.

plate to the strake of shell plating is made in short lengths to fit between the frames, the ends of the bar being bent, joggled and shaped to fit close to the frame bars and to extend inwards a little beyond the toe of the frame. The vertical flanges at the ends of the short angles meet each other and are riveted together. In Figure 42, A indicates the frame, B and B the intercostal angle bars fitted into the bosom of the frames; the horizontal flange is riveted to the stringer plate and the vertical flange to the shell plating, the end vertical flanges being riveted together.

Bulkheads are vertical partitions arranged transversely or longitudinally to form walls to subdivide the ship into convenient sections for stores, living accommodation, cargo, etc.

Transverse Watertight Bulkheads, however, enter largely into the main structure of the vessel, their principal function being to impart

strength and to add to the safety of the vessel by subdividing the hull into self-contained watertight compartments so that in the event of one or more compartments being flooded there would still be left sufficient reserve buoyancy to keep the ship afloat. They also serve to reduce the risks from fire by confining an outbreak to one hold.

The Number of Watertight Bulkheads is regulated by the length of the ship, but steam vessels must have at least four, a collision bulkhead placed at a distance of not less than 5 per cent., that is, one-twentieth of the vessel's length abaft the stem measured at the waterline; a bulkhead before and another abaft the engine and boiler space and an after peak bulkhead placed in a position to enclose the shaft tubes in a watertight compartment. Additional bulkheads are fitted with increase in the length of the vessel. When over 285 feet 5 bulkheads are fitted; when over 335 feet, 6 are fitted; when over 405 feet, 7; over 470 feet, 8 and over 540 feet, 9.

Watertight bulkheads extend to the shell plating on each side and from the floor to the upper deck. Such a large area of plating must be efficiently stiffened, not merely to prevent it buckling under pressures but more particularly to withstand the great pressure of a body of water on one side only in the unusual event of the compartment accidentally becoming flooded through stranding or collision. The pressure of water would be greatest at the bottom, and so the lower strakes of plating are increased in thickness and the relative thickness of all the plating depends on the spacing and strength of the stiffeners that are fitted. The stronger the stiffeners and the closer they are spaced the thinner may the plating be.

Collision Bulkhead stiffeners are stronger than for other bulkheads and the plating is made thicker to withstand the slashing of free water should the compartment be laid open to the sea by collision.

Bulkheads make the section where they occur perfectly rigid and overstrong so that the excessive local strength has to be distributed by means of brackets to the adjoining members of the hull, viz., to stringers, keelsons, shell plating, deck plating, etc., and these components pass it on throughout the structure and maintain a continuity and uniformity of strength.

Bulkheads.—Figure 43 illustrates a side view and front view of a bulkhead. The plating *A* may be arranged transversely or vertically, in this case transversely.

B indicates the vertical stiffeners with their top ends bracketed to the watertight flat above, and their bottom ends to the inner

bottom plating b_2. The brackets b_1 and b_2 must extend one beam space and one floor space adjacent to the bulkhead in order to get a rigid connection and support.

The vertical stiffeners C above the watertight flat are of lighter section.

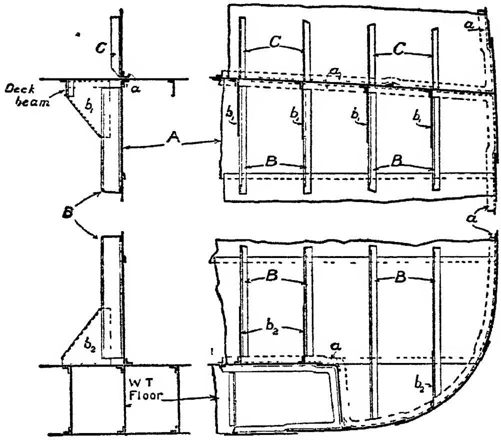


Fig 43 —Bulkhead.

Watertight connection round the margin of the bulkhead plating is obtained by a boundary angle a which is riveted to the shell plating and to the deck plating. The boundary angles are shown dotted in the figure as they are on the reverse side of the plating, and at the upper flat it will be noted that the boundary angle is fitted above and below the deck plating. The edge of the bulkhead plating at the ship's side fits in between the flanges of the frame and of the boundary angle and these are riveted to the shell and to the deck plating although sometimes only one angle may be fitted. The punching of these rivet holes introduces a double row of perforations round the whole girth of the ship thus introducing a source of weakness which is not fully restored by filling the holes with rivets. The positions of the transverse bulkheads in a ship fitted in this way may be located by looking along her sides and observing where the double lines of rivets appear.

The efficiency may, however, be regained by fitting broad liners behind the frames connecting the bulkhead to the shell plating instead of narrow ones the breadth of the frame flange only. These special

liners fit hard against the inner sight edges and level up the space between the outer strake of shell plating and the fore-and-aft flanges of the frame and boundary angles as indicated in Figure 44 where *A* represents an outer strake, *B* the bulkhead liner, *C* the frame bar, *D* the boundary angle, *E* and *E* the double row of rivets, and *F* the bulkhead plating.

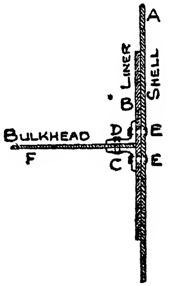


Fig. 44.

Watertight Longitudinal Bulkheads are made equal in strength and have stiffeners equal to those fitted to transverse bulkheads of the same depth. Midship longitudinal bulkheads when fitted in lieu of hold pillars, as in *Caledonian Monarch*, are stopped at the ends of hatchways.

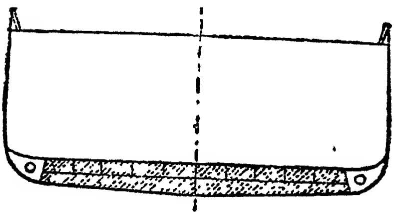
A Deep Tank to take water or cargo is fitted in many ships abaft the engine space, and when a second one is fitted it is usually placed just forward of the boiler space, as this arrangement puts the ship down in the water on nearly an even keel. Deep fore peak and after peak tanks for water ballast serve as trimming tanks in addition to increasing the displacement of the ship when filled.

The construction of a deep tank consists simply of placing a watertight transverse bulkhead at each end of the compartment, but the locality must be increased in strength to withstand the internal pressure of water. The transverse bulkhead in addition to the vertical stiffeners is further strengthened by horizontal stiffeners the ends of which are bracketed to stringers.

A centre line division, not watertight, is fitted to take the place of midship pillars and to act as a wash plate. It is connected to the deck and to the double bottom by double angles and strengthened by closely spaced vertical stiffeners bracketed at top and bottom to beams and floors respectively. Wash plates are also fitted in peak tanks.

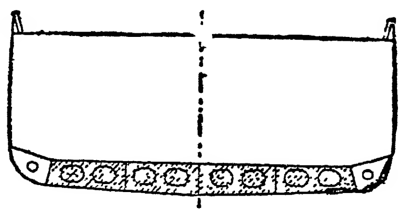
Deck beams are fitted at every frame in the way of deep tanks, the beam knees and side frames being made larger than elsewhere.

Pillars are fitted in the deep tank between the centre line division and the ship's side to prevent the deck from buckling under the stresses which may be set up by the swishing of the water in a slack tank when the ship is in a seaway. Sometimes specially deep tank girders are substituted for pillars in order to get a clearer space for cargo. The girders are connected to the deck beams and when they are deep enough they serve as wash plates in lieu of the centre line division. Deep tanks are fitted with watertight hatches, one on each side of the centre division, the steel plate cover of the hatches being clamped and screwed down



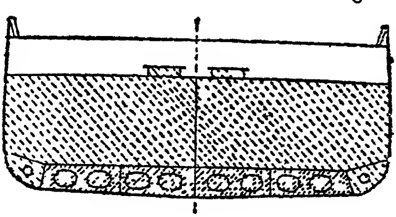
DOUBLE BOTTOM.

Fig. 45.



CELLULAR DOUBLE BOTTOM.

Fig. 46.



DEEP TANKS AND CELLULAR DOUBLE BOTTOM.

Fig. 47.—Note the Small Watertight Hatches in 'Tween Decks.

tight on their coamings with screw bolts and made effectively watertight by packing. See also page 603.

Various water ballast arrangements are shown in the foregoing illustrations, the hatched lines indicating water.

HATCHWAYS.

Cargo Hatches in ships engaged solely in carrying cargo are made as large as possible to facilitate rapidity in loading and discharging. These large openings in the deck necessitate severing many of the beams, thus reducing very considerably the transverse strength. Beams are

also cut at the engine and boiler spaces. Refer to the deck plan of *Caledonian Monarch* and note the gaps made by the hatches in the upper deck which, of course, are repeated in the lower deck.

The Hatch Openings not only weaken the vessel structurally but also affect her seaworthiness unless every precaution is taken to restore the lost strength by means of additional girders either permanent, portable or both, and by brackets, hatch coamings, covers and tarpaulins to resist the inroad of heavy seas breaking on board.

Half Beams are those that are cut to provide the hatch openings. They are fitted to every frame, their inner ends being secured to the lower edge of the hatch coaming by angle lug pieces, one flange of which is riveted to the coaming and the other to the beam.

The Coamings of upper deck cargo hatches should have a minimum height above the deck of 2 feet and be stiffened all round the upper edge with angle bars and half round sections. The lower edge extends a little below the bottom of the beam and is usually rounded off (as shown in Figure 48) to take away the sharp edge.

The inner ends of the cut beams are supported by pillars spaced not more than four frame spaces apart, but should this arrangement of pillaring be departed from the coaming must then be bracketed to the deck when it is over 15 feet long. The deck plating is doubled at the hatch corners. Rounded corners are more graceful in appearance and stronger than square ones, as the coaming plate is then continuous all round the hatchway instead of being joined by an angle bar. An angle bar connects the deck plating to the side of the coaming and ensures a watertight fit.

Portable Hatchway Beams are fitted inside the coaming to form a framework for the wooden hatch covers to rest upon and also to restore some of the lost transverse strength due to cutting the beams. The athwartship beams are spaced so that the unsupported length of hatch cover does not exceed 4½ feet, with a slight modification in the case of hatchways in spaces fitted exclusively for the accommodation of passengers and light goods. The portable web beams are stiffened at their upper and lower edges with double angle bars. All hatchway fore and afters are supported at their ends on a 3-inch ledge formed by steel carriers fitted to the coamings and to the ends of the portable webs. The wooden hatch covers are solid and at least 2½ inches thick; the angles on which they rest are at least 2½ inches wide.

The Cleats to take the battens and tarpaulins are spaced not more than 2 feet apart and the end cleats are placed not more than 6 inches

from the hatchway corners Battens, wedges and tarpaulins must be efficient for their purpose and in good condition.

In Figure 48, A is the side coaming, B the end coaming, C is the portable athwartship web beam with lightening holes in it. c_1 and c_2 are double stiffening angles on the web beam, c_3 and c_3 are the carriers on the web beam to support the ends of the fore and afters K and H. f represents the wooden hatch covers. a_3 is a half round section to stiffen the upper edge of the coaming plate. a_1 the angle bar to make a watertight connection between the deck plating and the coaming. a_2 are double vertical angles to receive the ends of the athwartship beam, showing holes to take screw bolts and nuts so that the beam will act as a tie to bind the sides of the coaming together. d_2 is a cut beam.

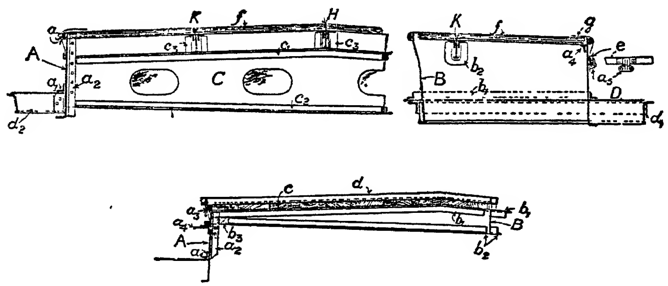


Fig. 48.—Hatch Coaming.

Referring to the drawing of the end coaming plate B. we see b_2 the carrier to receive the fore and after K. b_1 is the angle connecting coaming to deck plating D. d_1 is a continuous transverse beam to which the lower edge of the coaming is riveted. f indicates a wooden hatch cover resting on the angle bar head ledge a_4. g indicates the tarpaulin turned over the corner of the coaming and reaching down to the cleat a_3, where it is gripped between the flat steel batten e and the coaming when the batten is wedged up tight.

The lower figure represents a portable beam fitted in small hatches between 10 and 16 feet in length. B is the web plate, and b_1 and b_2 are double stiffening angles, and b_3 is a doubling plate. See also page 602.

a_1 is the angle connecting the coaming plate A to the deck plating.

a_2 indicates double vertical angles to stiffen the coaming and to receive the ends of the athwartship beams. a_4 is a bulb angle stiffener round the coaming. c represents the wooden hatches, and d a channel section angle bar placed across the hatch to make the covers more

secure at sea and to lock up the hatchway in port. The ends of this bar project a little beyond the coaming and are secured with a clamp at a_3.

The framework of web beams and fore and afters within the coamings offer a very precarious foothold and many accidents have occurred through men losing their balance and falling into the hold when taking off and putting on the sections of wooden hatch covers and strongbacks. The modern tendency is to fit steel hatch covers either of the hinged type to tip up in one piece like a lid, or of the roller pattern which may be in one piece, or in sections, and rolled back horizontally to uncover the area of hatchway required. The steel covers are stronger and less vulnerable to the inroads of heavy seas than wooden covers.

The Stem Bar is a forged bar of iron or steel. It is scarphed to the bar keel when one is fitted and forms a continuation of the latter. The connection between a flat plate keel and the stem bar is formed by

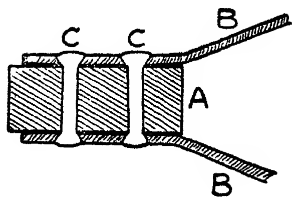


Fig. 49.

troughing, or dishing, the forward end of the keel plate round the end of the stem bar and riveting both together. The stem is also connected to the structure by the shell plating, the strakes of which lap on each side of the stem as in Figure 49 where A is the stem bar, B and B the shell plating, and C C a double row of rivets.

Panting is more likely to occur in sharp vessels than in bluff-bowed vessels. The curvature of a bluff bow is an element of strength in itself and helps to resist panting.

Panting Beams are fitted across the interior of the vessel, usually on the fore side of the collision bulkhead.

Their strength is distributed over the frames and shell plating by means of the stringers to which they are connected by brackets, or **gusset plates.** Two brackets used together are sometimes called a **gusset.** The stringers themselves are sometimes stiffened and widened where panting might occur. Other parts of the vessel which help to stiffen the frames and shell plating and thus prevent panting are

the chain locker bulkhead, collision bulkhead, floors, breasthooks, crutches and transom (Figure 50).

Breasthooks and Crutches are horizontal plates fitted at the forward and after extremities of vessels, and riveted to the ends of stringers and keelsons on each side, thereby joining the two sides of the vessel together. They are termed **breasthooks** when in the bow, and **crutches** when in the stern. Breasthooks and crutches are also formed by the junction of the stringer plates themselves at the ends of a vessel.

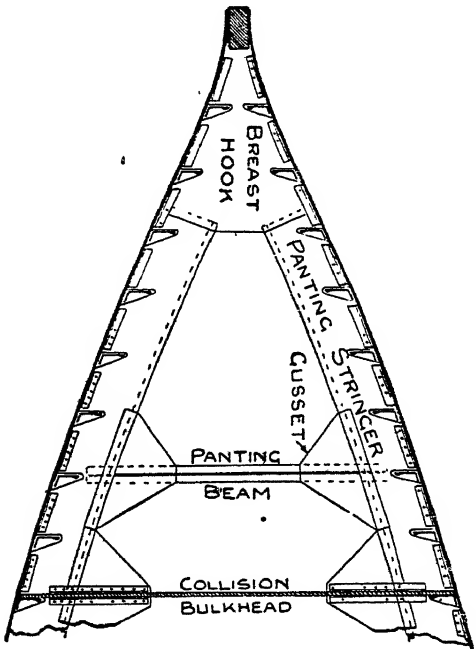


Fig. 50.—The Strengthening of the Bows.

The Stern Frame consists of the propeller post and rudder post. These two important parts of a single screw steamer are commonly forged or cast in one piece, though sometimes they are made in different pieces and "scarphed" together.

The body post is made of curved form at the top and bottom where it merges into the rudder post, the space between the two forming the screw aperture.

In large screw steamers the body post is also extended above the

screw aperture to a deep floor above the lower deck, to which it is strongly attached.

The rudder gudgeons are 4 to $5\frac{1}{2}$ feet apart, according to the size of the vessel.

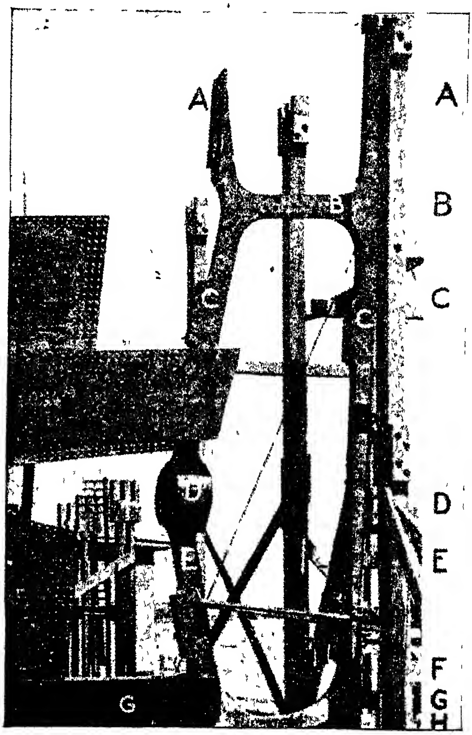


Fig. 51.—A Stern Frame.

In Fig. 51, *A* is the palm on the extended body post for connecting frame to floor plate and transom plate; *B* is the arch piece, scarphed to body post and to the stern post at *C*. *D* is the propeller shaft boss. *E* the body post. *H* is the sole piece, the end of which extends forward and is connected to the hull by dishing, that is bending and shaping, the keel plate against the sole piece to which it is riveted. The stern frame and its connections are made strong in order to counteract the strain caused by the vibration and continual working of the propeller.

The Transom Frame is the aftermost frame in the ship, and the "transom floor," which is at least $1\frac{1}{2}$ times the depth of the midship floor, or 6 times the thickness of the stern frame, is connected to the stern post by means of an angle bar on each side of it. The shorter pieces of frame which support the overhanging counter of an elliptical stern are called "cant frames," they radiate from the transom and are bracketed to the transom floor. The outer ends of the cant beams are kneed to their respective cant frames.

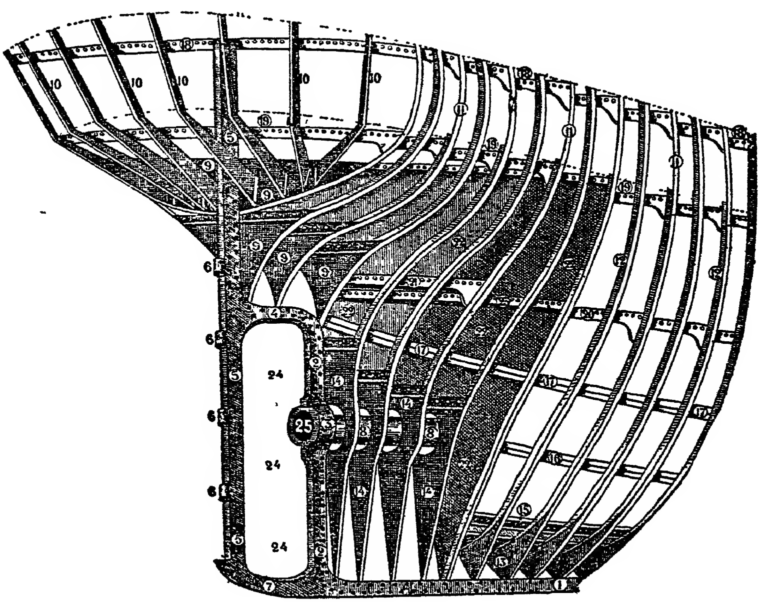


Fig. 52.—Stern Framing.
By permission, *From Truck to Keel* (Captain H. Paasch).

1. Keel
2. Propeller post
3. Boss of propeller post
4. Arch-piece of stern frame
5. Stern post
6. Rudder gudgeons
7. Sole-piece of stern frame
8. Stern tube
9. Transoms
10. Cant frames
11. Frames
12. Reversed frames
13. Floors
14. Deep floors
15. Keelson
16. Bilge stringer
17. Side stringer
18. Upper deck beams
19. Main deck beam
20. Lower deck beam
21. Panting beam
22. Stuffing box bulkhead
23. Horizontal bulkhead stiffener
24. Screw aperture
25. Shaft hole of propeller post

RUDDERS.

The most common form of rudder in vessels of moderate speeds is the ordinary **Single Plate Rudder** which turns about an axis at its forward edge, the hingeing arrangement being in the form of round "pintles" attached to the "stock" of the rudder which ship into "gudgeons" which are part of the rudder post. The weight of the rudder is taken by the bottom gudgeon of the stern post into which the lower pintle, the "bearing" pintle, fits. The end of the bearing pintle is rounded and bears on a hemispherical steel disc placed in the gudgeon socket, the purpose being to reduce the area of the metal to metal surface and so minimise friction. When this disc gets worn it is replaced by another when the vessel is in drydock.

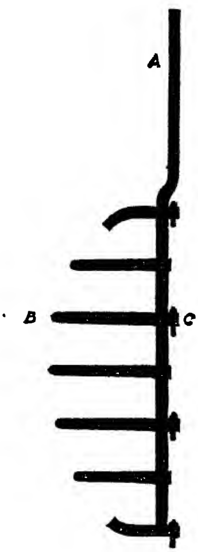


Fig. 53.

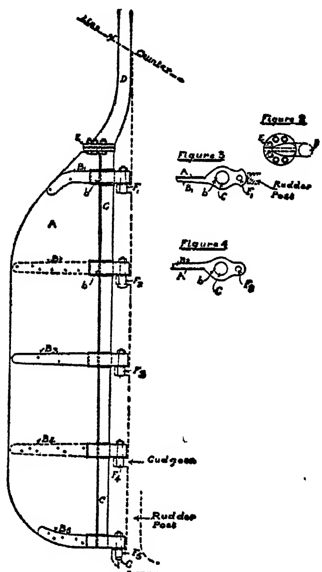


Fig. 54.—Single Plate Rudder.

Figure 53 shows the stock *A*, the arms *B*, and the pintles *C*, of a small rudder before the blade is slipped into position, the arms being on alternate sides of the blade.

Figure 54 illustrates the detail of a single plate rudder. *A*, the rudder blade, the forward edge of which fits into a narrow keyway scored down the after side of the rudder stock *C*. B_1 to B_5, the arms which are shrunk on the stock *C* at *b*. They are also shown in plan, Figure 54 (3 and 4), the lettering indicating the same parts.

D is the upper part of the rudder stock *E*, a horizontal coupling connecting the two parts of the stock together by means of six screw bolts and nuts shown in plan, Fig. 54 (2). The purpose of the coupling is to be able to disconnect the rudder when necessary. F_1 to F_5 are the pintles. F_2 is the locking pintle to prevent the rudder jumping out of the gudgeons when the vessel pitches. It has a head or collar on the under side of the gudgeon to prevent it lifting.

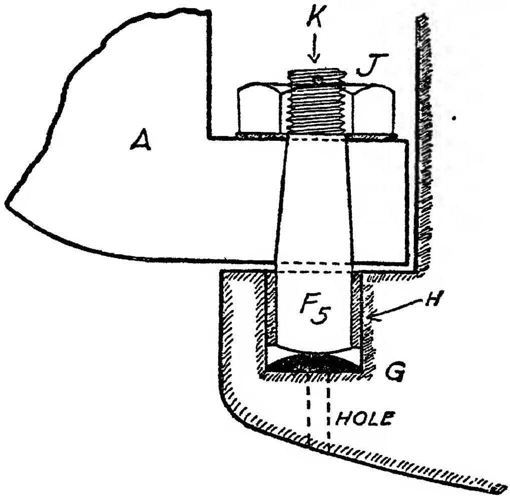


Fig. 55.—The Bearing Pintle.

F_5 is the bearing pintle resting on the steel disc *G* (Fig. 55). There is a small hole from the bottom of the socket to the heel of the post, large enough to take a punch for knocking out the worn disc when the rudder is jacked up in drydock. *H* is a hard wood bush of lignum vitae; *J* the nut, and *K* a steel pin fitted to all nuts at the rudder to keep them from working back.

The top end of the stock is steadied at a watertight flat by passing through a stuffing box made watertight by packing screwed down hard between glands.

Stop Cleats fitted on the rudder or on the rudder post in small vessels prevent it from going beyond about 38° on either side of amidships, 35° when hard over being the angle of maximum working efficiency. In larger vessels stop cleats or buffers are also fitted on the deck in the way of the quadrant, but these should stop the rudder at a slightly smaller angle of helm than the stops on the rudder.

There is quite a variety in the shapes of rudders, both in the ordinary and balanced types. With the increased speed and size of modern ships more and more attention is being given to the streamline shaping of rudders and the methods of their suspension with a view to reducing the resistance offered by the rudder to the vessel's forward motion. The whole area of an ordinary rudder (Fig. 54) is abaft its turning axis,

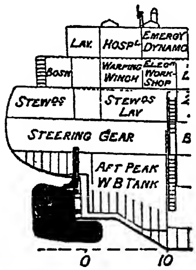


Fig. 56.

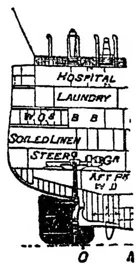


Fig 57

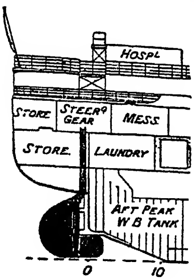


Fig. 58.

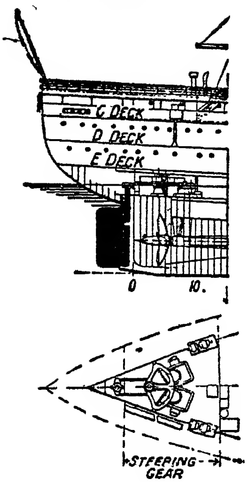


Fig. 59.

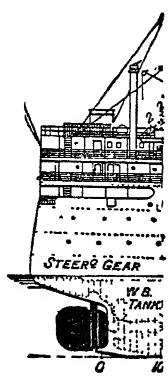


Fig. 60.

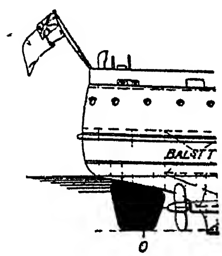


Fig. 61.

and the "centre of pressure" exerted by the mass of water impingeing against it is a point somewhere between the middle of its breadth and the forward edge. This point alters in position with the angle of helm and is approximately about one-third the breadth of the rudder abaft the pintles. Considerable power is therefore needed to turn it, and so balanced rudders are fitted in fast ships having large rudders and where quick rudder movements are required.

A small area of a balanced rudder projects forward of the rudder post and acts as a partial balance by bringing the centre of pressure nearer to the axis and relieving the rudder head of considerable torsional stress when the helm is put over either way and, of course, reducing also the steering engine power required to do so. Balanced rudders

Fig 62.—An Oertz Streamline Rudder, and Draught Figures.

have greater fore-and-aft length but less height than ordinary, and the design of the stern post has to be suitable for the type of rudder fitted.

Figures 56 to 61 illustrate various shapes of rudders. In 56, 57 and 58 the pintle shown at the bottom does not support the rudder but serves only as a steadying piece, the weight being taken inboard on the stern post. The steering engine in 59 is shown just over the rudder,

which is an ordinary unbalanced one. No. 60 is a type supported on a bearing pintle, and No. 61 is a "spade" rudder.

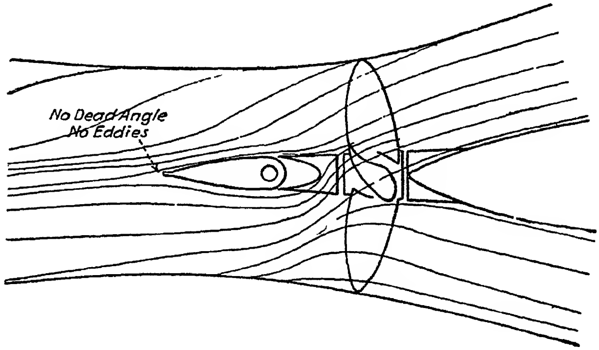


Fig. 63.—The Streamlines of an Oertz Rudder.

Figure 62 is an Oertz streamline rudder. The part on which the draught marks are painted is fixed to the stern post and designed to smoothen out the confused flow of water thrown against the rudder by the action of the propeller and the streamlines of the vessel as indicated in Figure 63, which shows, in plan, the form of the Oertz rudder and the local flow of water.

The following plates are inserted by courtesy of Submarine Boat Corporation, Newark, N.J.,

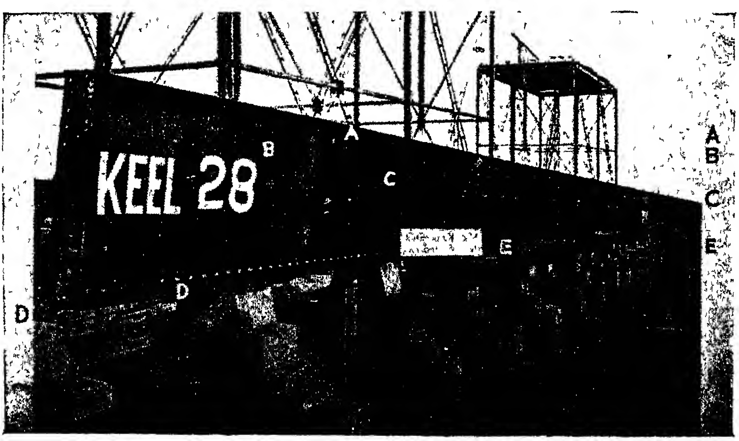


Fig. 64.—The Keel laid on the Blocks.

Figure 64, *C*, the centre line keelson; *B*, vertical angles to take

floors; *A*, angle bar to secure tank top to keelson; *D*, angle bars to secure keel plate to keelson; *E*, the keel plate.

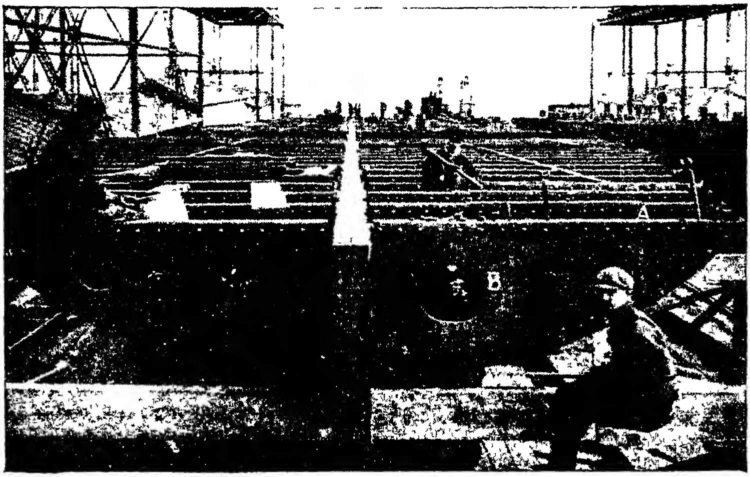


Fig. 65 —Constructing Floors.

Fig 65 shows construction of floors; *A*, floors attached to centre line keelson and angle bars riveted to their upper edges; *B*, lightening hole.

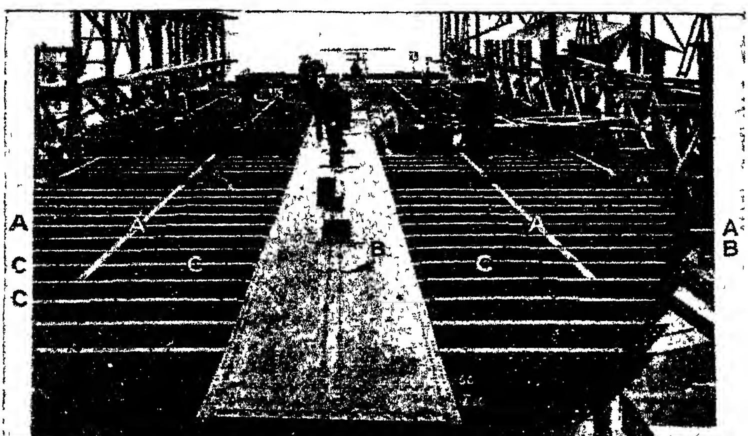


Fig. 66.—A Stage Further on.

Fig. 66, *A* the intercostal side longitudinals; *B*, the centre strake of inner bottom plating which is a sunk strake; *C*, short narrow liner pieces on the reverse angle of the floor to make a level foundation for the raised strake of the tank top plating.

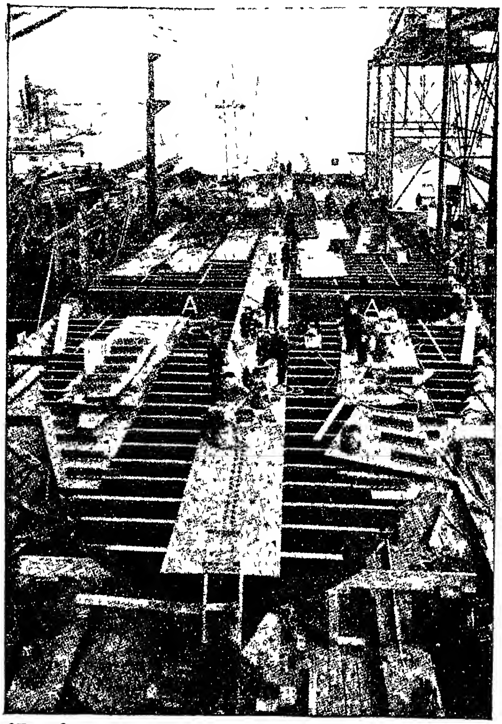


Fig. 67.—Getting on with the job. First Frame Erected.

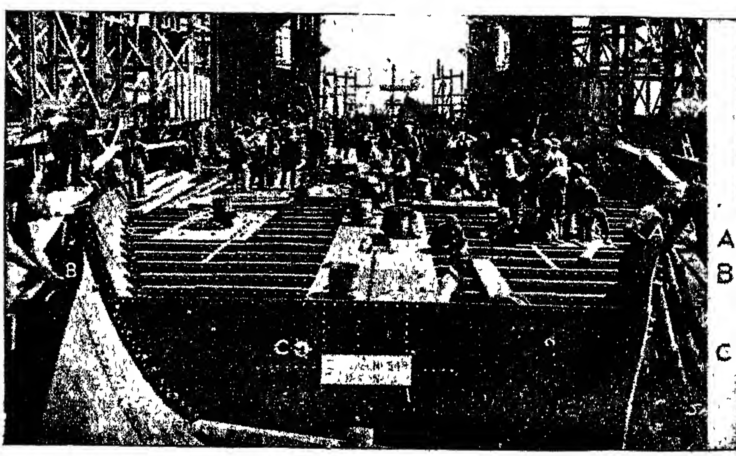


Fig. 68.—A Busy Crowd.

Figure 68, *A*, boundary angle bar at bulkhead; *B*, bolting shell plating to angle; *C*, hole for pipe flange of pump connections. Plate *C* is the lower one of a bulkhead.

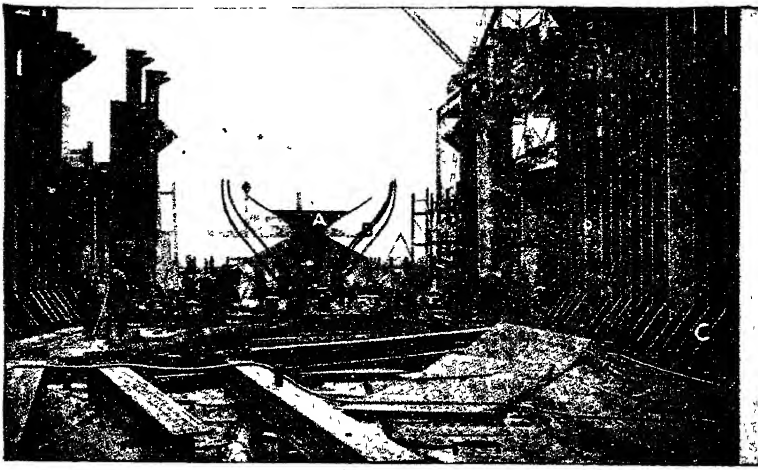


Fig 70 —View Looking Aft.

Figure 70, *A*, after peak bulkhead; *B*, side frames at the after body of the ship; *C*, bracket plates securing the lower end of the frames to the tank top. The double bottom extends to the shell plating and there is no bilge pocket in this type of ship.

Fig. 71 —An Inside View of Frames and Collision Bulkhead.

Figure 71, *A*, beam knee; *B*, a pillar of *H* section; *C*, web frame. Web frames are sometimes introduced when beams are omitted in engine and boiler spaces and abreast hatchways in order to compensate for loss of transverse strength. They consist of a web plate riveted to the frame and stiffened on its inner edge by two angles. The beam and beam knees on web frames are of heavier scantlings than those at ordinary frames.

Note the clips *D* on the tank top to take the bracket, not yet in place, for securing the lower ends of the frames.

The Stern Tube.—The propeller post is swelled out to form a boss for the shaft. The "tail shaft" *A* passes through the stern tube *B*, which

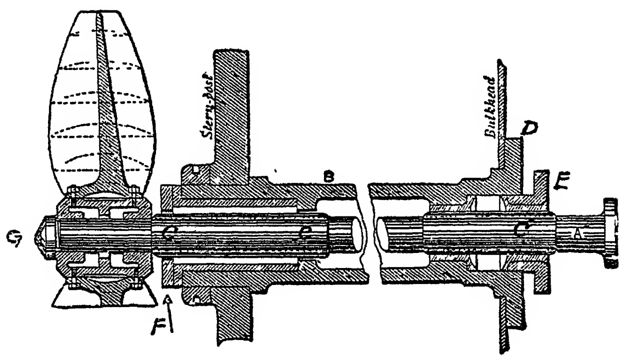


Fig. 72.—Stern Tube and Tail End Shaft.

carries the bearings *C* for the shaft to revolve upon. The stern tube is of cast iron or gunmetal with a flange *D* on its forward end bolted to the after watertight bulkhead; the end is fitted with a stuffing box and gland *E* to prevent water entering the ship. The outer end of the stern

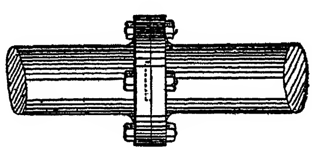


Fig. 73 —A Shaft Coupling.

tube passes through the stern post and is secured thereto by a screw nut *F* on the end of the tube. The bearings work in strips of lignum vitae recessed into the bush and kept in position by means of a check plate. The lubricant is sea water and a drain pipe is led through the bulkhead

with a cock on it to enable the engineer to draw water from the stern tube, so that its temperature may be tested to ascertain if the bearings are working cool. A strong massive nut *G* screwed on to the end of the shaft prevents the propeller from working off.

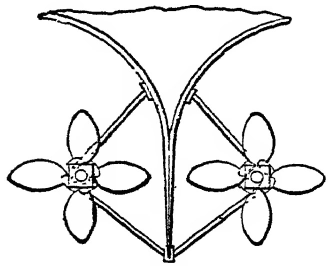


Fig. 74—Twin Screws.

Refer to the profile of *Caledonian Monarch* and note the stern tube and the spare tail shaft stowed in the recess at the after end of the tunnel. To unship a propeller in drydock the nut must be unscrewed and the propeller slung by tackles hooked on to eyebolts for the purpose on each side of the ship's stern. The gland is unscrewed and the tail shaft uncoupled from its adjoining length of shafting, and which has

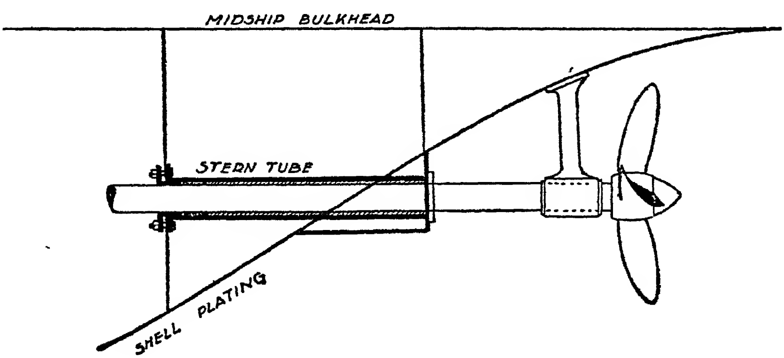


Fig. 75—Stern Tube for Side Screw.

also to be removed to allow of the tail shaft being drawn straight forward, leaving the propeller suspended by the tackles. Repairs and rebushing of the tail shaft can then be executed.

The other lengths of shafting pass through bearings supported on widely spaced stools, the forward length being coupled to the thrust shaft

at the thrust block, which takes up the fore-and-aft pressure of propeller and passes the thrust on to the hull. The bush of the thrust block is provided with a number of thrust rings, which fit between corresponding collars on the thrust shaft, the propelling pressure being exerted on the forward sides of the collars and on the after sides of the rings when going ahead. The forward end of the thrust

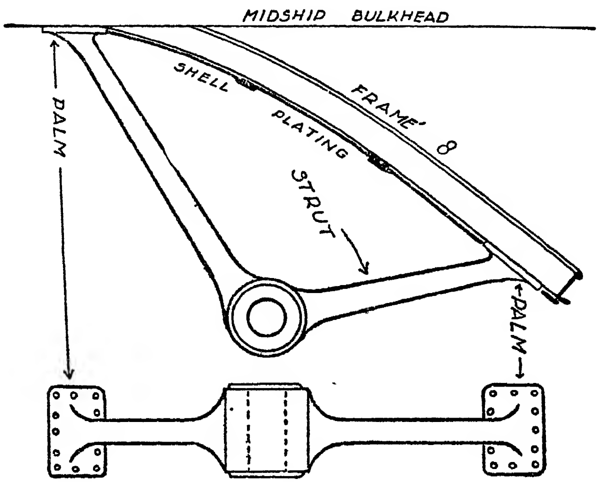


Fig. 76.—Detail of Strut for Shaft.

shaft is coupled to the crank shaft, which receives its rotary motion from the piston rods of a reciprocating engine.

The shaftings and stern tubes for the propellers of a twin screw ship are arranged in the same way as for single screw vessels.

The shaft abaft the bossing is sometimes supported by one or two struts as in Figs. 74, 75 and 76, but in many ships the shafting is enclosed by bossing the shaft, in some cases right up to the propeller.

Pipe Line systems for supplying, draining and transferring fresh water and sea water from and to the various compartments and to auxiliary engines are fitted in ships, the system being a very elaborate one in passenger vessels and oil tankers. A drainage system is necessary to remove by pumps any water which collects in the bottoms, bilges and tanks. The system usually consists of a main pipe throughout the

length of the ship, with a separate pipe for bilge suctions, led from the engine-room forward through the bilges and aft through the tunnel

Auxiliary suction pipes branch off from the main pipes to the different water ballast tanks and bilges, the main pipes being led to a valve chest in the engine room containing the several valves by which compartments and pumps may be so connected that any particular compartment can be emptied. The valves are of the non-return type to prevent the possibility of water passing in from the sea, or from water tanks into cargo and machinery spaces, or from one compartment to another.

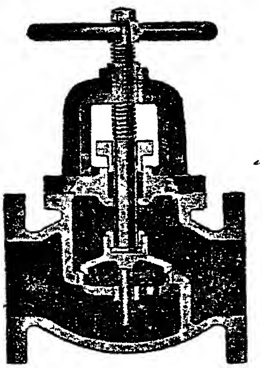


Fig 77 —Valve.

Bilge Suction Pipes are fitted with strum boxes or strainers, placed in accessible positions for inspection when the holds are empty and so constructed that they can be easily cleared when choked. Pipe lines are fitted with expansion joints or bends so that they may not be strained or fractured with the working of the ship. See page 604.

Sounding Pipes extending above the load waterline are fitted in each compartment and ballast tank, with a thick doubling plate under the bottom end of the pipe for the sounding rod to strike upon. Air pipes are also fitted at each end of ballast tanks, the caps of which must be taken off before the tank can be filled with water.

It is invariably the daily duty of the carpenter to sound all compartments, tanks and bilges, and to note on a board in the engine-room the depth of water in each as indicated by his sounding rod. It is also the duty of an officer on joining a new ship to become acquainted as soon as possible with the positions on deck of all sounding pipes, hand pump and sluice valve connections.

In oil tankers the air pipes are led a considerable distance up the

sides of the mast to carry clear of the deck the vapour given off by benzine, naphtha, gas-oil or any low flash spirit, and are fitted with automatic valves which are operated by the difference of pressure between the vapour in the tank and the atmosphere outside. When the pressure in the tank is the greater the gas presses the valve open and escapes into the atmosphere; and, conversely, when the pressure within the tank falls sufficiently below the pressure of the atmosphere, especially when pumping out oil, the valve opens inwards and the air passes into the tank and maintains an equality of pressure. Needless to say, these automatic valves require attention and must be opened out and examined periodically to ensure that they are working properly.

VENTILATION

The ventilation of large passenger ships with several heights of decks presents a difficulty which is satisfactorily overcome by either the **pressure** system or the **exhaust** system. In the pressure system fresh air is drawn down the ventilator by fans and forced through sheet-iron ducts to the various compartments; in the exhaust system, fans draw the foul air from the compartment and exhaust it up the cowls, the fresh air entering the ventilating ducts.

The Thermotank System is a combination of ventilating, heating and cooling. The air is drawn by fans into a casing, comes into contact with the surface of pipes and is then forced through ducts to the various parts of the ship. The temperature of the air may be left as it is, or heated by circulating steam through the pipes, or cooled by circulating brine through them.

Engine-room and Stokehold ventilators extend as far down into the compartment as practical, with branches leading to both sides of the ship, but fans are usually fitted in the bottom of the ventilators which extend up to the weather deck. The air is drawn down the ventilator and distributed as low down as possible, thus displacing the heated air and expelling it upwards through skylights or other outlets.

Cargo Spaces.—With most cargoes, and especially with those of a perishable nature, such as fruit, etc., ventilation is an important matter, and is necessary for the proper care of the cargo and to prevent deterioration. The neglect of this may result in the ship being held responsible for damage if it is proved that such damage might have been prevented by proper ventilation. When, however, the cargo contains anything of an inflammable nature, or which is likely to give off inflammable,

explosive, or poisonous vapour, proper and efficient ventilation becomes of vital importance, and neglect of this precaution may lead to disastrous consequences, possibly involving loss of life.

No system of ventilation will be efficient unless arrangements are made for the free exit of possible foul, damp, or vapour-laden air, as well as the introduction of fresh air, the object being to keep a circulation of air through the entire hold or compartment. Movable ventilators should be attended to so as to take advantage of the wind. If a hold or compartment is ventilated entirely by cowl ventilators, they should not all be turned to the wind. The one furthest to leeward should be open to the wind; the one furthest to windward should be turned away from the wind to allow free outdraft. See also page 606.

In fine weather, and *when the cargo is not of an explosive or inflammable nature, such as petroleum spirit, etc.*, the ordinary means of ventilation may be supplemented by taking off one or two of the hatches forward and aft. This will give surface ventilation. In special cases where additional ventilation is necessary, it can be obtained by rigging wind sails into an open hatch.

The gas given off from coal cargoes is of a light nature, and rises. It tends therefore to accumulate at the upper parts of the hold, and by a system of surface ventilation it will be passed away from the interior of the vessel. Petroleum vapour, on the other hand, is very much heavier than air, and thus accumulates at the bottom of holds or other spaces; and any system of ventilation, when carrying this spirit, to be effective, should be such as will withdraw the vapour-laden air from the bottom.

The holds of vessels, other than tankers carrying petroleum and other similar spirits, should not be ventilated by removing the hatches. Proper ventilators should be fitted extending to the bottom of the hold. These should have large cowlheads, the openings being covered with fine brass wire gauze.

All ventilation of crew spaces should be carefully attended to, and kept open, when carrying any of these dangerous substances.

No one should be allowed to enter any hold or compartment where there has been stowed any of these dangerous substances or liquids until they have been thoroughly ventilated. There are gases which it is dangerous to inhale, but which are odourless and give no warning of their presence.

The presence of dangerous gases can be detected by means of a safety lamp, specially devised for the purpose. If the light becomes

extinguished the atmosphere is in a dangerous condition. On no *account should a naked light ever be used for trying the atmosphere of any suspected place.*

ISHERWOOD SHIPS.

The vessels described so far have been designed on the transverse frame system, that is, the frames have been closely spaced with widely spaced heavy longitudinals laid across them. But longitudinal framing, invented by Sir Joseph W. Isherwood, Bt., and now popularly known as the *Isherwood* system, is extensively employed especially in the construction of oil tankers. The frames in this system are also closely spaced but arranged longitudinally, the transverse girders being massive and spaced widely apart, as in Figure 78, which represents a section of a tanker.

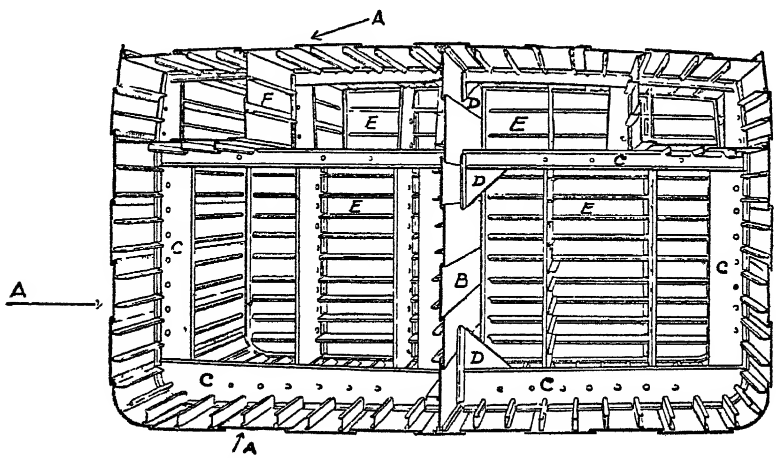


Fig. 78.—Isherwood Framing for Tanker.

A, are closely spaced longitudinal frames at the bottom, the sides and the decks.

B, middle line longitudinal bulkhead extending from the bottom of the tank to the top of the expansion trunk.

C, a strong transverse girder consisting of a deep floor plate, a deep vertical web frame in the lower hold united to a heavy lower deck beam; a smaller web frame in the 'tween deck is associated with an upper deck beam of proportional dimensions. *D*, brackets to secure floor plates and beams to the midship bulkhead; note the longitudinal stiffeners just showing on the left side of the bulkhead.

E, transverse bulkhead stiffened by horizontal angle bars, closely spaced, and further supported by widely spaced heavy vertical stiffeners

F, sides of expansion trunk. The space between this longitudinal bulkhead and the side of the ship is called the "summer" or side tank.

The trunkway, which extends the whole length of each tank, is about 7 or 8 feet in height and must not exceed in width 60 per cent. of the vessel's breadth.

The Isherwood system lends itself more readily to modifications in structure to meet special requirements than the transverse system, especially in offering economy in the work of construction, great longi-

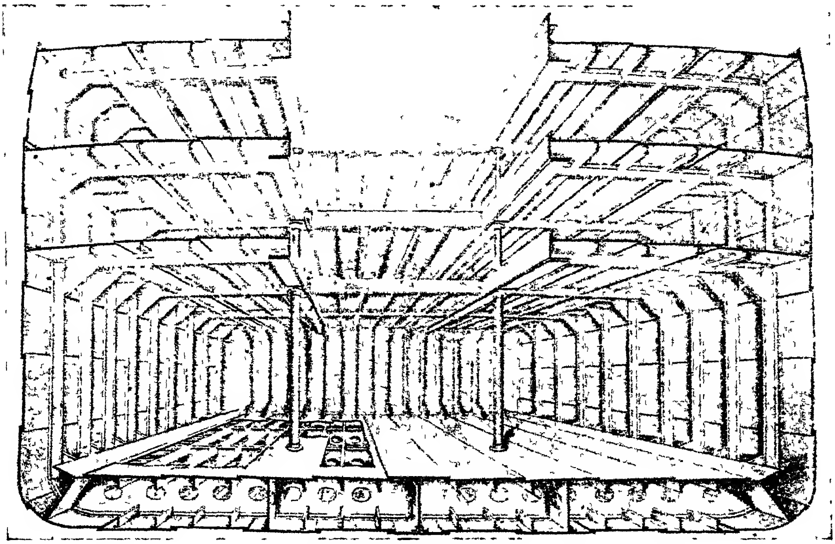


Fig 79—Isherwood Framing Cargo Vessel.

tudinal strength, convenience in subdividing the ship, and in providing clear holds for cargo. The rules of the classification societies are sufficiently flexible to allow of various modifications in the details of ship construction so that combinations of transverse and longitudinal framing; web frames, deep frames and ordinary frames; deep and shallow stringers; rolled section beams and built beams; solid pillars, tubular pillars and built pillars, etc., may be introduced into various parts of the same ship. The longitudinal frames of Isherwood ships converge towards the bow and stern and come too close together so that the transverse system of framing is introduced at the ends.

Figure 79 is an example of an Isherwood ship for general cargo purposes, in which longitudinal framing is adopted for the double bottoms, and decks, with deep frames at the sides and transverse beams at every third frame Note the vertical stiffeners on the bulkhead bracketed at top and bottom to the longitudinal frames, and the tubular pillars at the hatch corners. Tubular pillars have solid heads and heels.

Corrosion.—When steel is exposed to the action of air, or of moisture, particularly if it be salt-laden, rust soon appears on its surface which penetrates into the plating and corrodes it away. Oxygen is necessary to the formation of rust, hence the reason why it is necessary to exclude air from direct contact with iron and steel by keeping it well coated with paint. New ships should be well coated, especially round rivet heads, butts and laps.

When corrosion sets in all rust must be scaled or hammered off, the bare metal thoroughly scraped, cleaned and dried before applying a priming coat of paint. Several coats should be given in succession, allowing sufficient time between each to allow the previous coat to dry hard.

Sometimes butt straps and plate landings show signs of moisture and when this occurs the "weeping" joints are made tight by cleaning out the crevices with a wire brush and caulking the edges, which is just burring up the edges of the plating with a chisel and hammer to close up the joint.

Paint is composed of two ingredients, a pigment and a vehicle. The pigment is the solid particles, the vehicle is the oil or liquid portion. The principal pigments are white lead, zinc oxide and red lead; the principal vehicles used on board ship are linseed oil, turpentine and varnish. Linseed oil is a drying oil and turpentine is used for thinning out. Driers are used to expedite the drying of the paint. The drier acts on the oil but not on the pigment, and too much drier causes the paint to crack and peel off. Copal varnish is mostly used for woodwork.

Red lead is supplied as a dry powder. It is a very good first coating, is strongly adhesive, sets hard and dries quickly. The following quantities will make up 1 gallon of mixed paint ready for application, its covering power being about 50 square yards:—20 lbs. red lead; 5 pints linseed oil; 2 gills turpentine; 2 gills drier.

White lead produces a hard layer and is used as an undercoating. It has more body than white zinc, which is a thinner and lighter pigment and retains its pure colour better than white lead. White zinc is used for

surface decorative work. These paints are supplied ground in oil so that, on board ship, it is only necessary to add linseed oil and stir well to reduce it to the desired consistency; add a small quantity of driers.

It works out as a rule that 1 quart of oil reduces 6 lbs. of paint to a suitable consistency having an average covering power of 50 square yards. The pigment settles to the bottom of the pot and so must be stirred with a stick at frequent intervals during painting operations. When the job is finished any residue of paint should be poured back into the container and the pot wiped out clean to be ready for next time, otherwise, skins quickly form on the inside of the pot if paint is left in it.

Brushes should be rubbed out as dry as possible and put in water overnight, but if they are not to be used again for some time they should be washed out in hot water and soap. Varnish brushes should be put in linseed oil to keep them soft. All brushes when stored away should be hung up or laid flat and never left standing on their bristles.

Bottom Compositions.—Underwater paints are applied in dry dock. They are classed as anti-corrosive, anti-fouling and boot-topping. They are expensive paints, specially manufactured with heavy pigments which settle rapidly and have to be kept stirred continuously during application, and a quickly evaporating vehicle which causes the paint to dry almost as quickly as it is put on. The job has to be done quickly.

Anti-corrosive is first applied to act as a foundation and as an insulator to prevent the destruction of the steel. The plating must be first freed from grease and scum as the paint will not adhere to a greasy surface and will soon flake off.

Anti-fouling is coated over the anti-corrosive, its purpose being to retard marine growth, barnacles and grass mostly. Anti-fouling composition consists largely of oxide of mercury, and if it comes into contact with the bare steel it will set up corrosion, hence the need of an anti-corrosive as an insulator. Anti-fouling coating is usually carried up to the light load line only and a cheaper paint, called boot-topping, applied between the light and load water marks when the ship is afloat.

The cellular double bottoms, inside of tanks, are usually coated with a layer of cement deep enough to cover the rivet heads (mixture—two parts sand to one of cement), then cement-washed occasionally. See also page 613.

Wetted Surface.—The area of the underwater form of a ship is given by the equation:—$WS=L\ (1{\cdot}7d+Cb\times B)$ where

WS is the skin surface area
L the length of the ship
d the mean draught
Cb the ship's block coefficient
B the breadth

This equation is used in some calculations dealing with the frictional resistance offered by the surface area of the under water body of a vessel. It may also be used to estimate the quantity of paint required to cover an area of shell plating from a given draught downwards by dividing this surface area by the known covering capacity of the paint.

The coefficient of a vessel is not always known and in such cases the manufacturers of special paints adopt empirical equations based on the results of experience and the average covering power of their own products, when they wish to estimate the quantity to send to the dry dock. Here is one such equation:—

Cwts $= L\ (B+d)$ expressed in square yards and divided by 350 square yards per cwt.

Such equations can only give a rough approximation as the covering power of patent compositions depends upon the consistency of the paint, the temperature, the manner in which it is applied and the character of the coated surface. Allowance has also to be made for considerable waste owing to the awkwardness of working under the ship and the haste due to the economic urgency of getting the vessel out of dry dock as quickly as possible.

Example.—Ship 400 ft. long, 54 ft. beam, block coefficient $=\cdot 8$. Find the amount of antifouling composition required to cover the bottom up to 15 ft. draught, assuming that 1 cwt. of composition covers approximately 3000 sq. ft.

(i)
$$\begin{aligned} WS &= L\ (1{\cdot}7d + Cb \times B) \\ &= 400\{(1{\cdot}7 \times 15) + (\cdot 8 \times 54)\} \\ &= 400\ (25{\cdot}5 + 43{\cdot}2) \\ &= 27{,}480 \text{ sq. ft.} \end{aligned}$$
$$\therefore \text{cwts.} = \frac{2748\cancel{0}}{300\cancel{0}} = 9{\cdot}16 \text{ cwt.}$$

(ii)
$$\begin{aligned} \text{Surface Area} &= L\ (B+d) \\ &= 400\ (69) \\ &= 27{,}600 \text{ sq. ft.} \end{aligned}$$
$$\text{cwts.} = \frac{276\cancel{0}\cancel{0}}{30\cancel{0}\cancel{0}} = 9{\cdot}2 \text{ cwt.}$$

Scantlings.—The term "scantlings" often appears in descriptions of ship construction, and it would be as well to clear it off here by defining "scantling" as the term used to indicate the sizes of the different component parts of a ship. The sizes are given in the Rules and Regulations of

the Classification Societies, against the scantling numbers of the ship, in the form of a series of Tables which give very precise information regarding the structure. The Tables are not of much interest to anyone other than those responsible for the building of the ship, nevertheless they illustrate to the casual reader the scientific basis underlying the design and construction of a ship, and, incidentally, they impress us with the fact that no one has a free hand to build a merchant ship in any way he fancies.

The numerals are derived from the dimensions of the proposed ship, the bigger the ship the bigger will her numerals be and the heavier will be her scantlings. The depth D of the proposed ship regulates the spacing and the sizes of the side framing and the dimensions of the floor plates. The numeral D is qualified by another number referred to as d when entering the Tables, d being the vertical depth at the middle of the ship's length measured from the top of the beams at the side of the lowest deck down to the top of the floors, or to the top of the double bottom.

The "First Longitudinal Numeral" is length × depth ($L \times D$), and this number regulates the sizes of all the components forming the double bottoms also flat plate keel, shell plating, propeller boss plates, etc. The "Second Longitudinal Numeral" is $L \times (B+D)$, that is breadth added to depth and multiplied by length. This number regulates the scantlings of the topside structure, such as sheer strake, stringer plates, deck plating, etc. See also page 542.

The dimensions of *Caledonian Monarch* are length between perpendiculars 430 feet, moulded breadth 56 feet, moulded depth 30 ft. 6 in.

Her numerals would be $D = 30{\cdot}5$

First numeral $L \times D = 430 \times 30{\cdot}5 = 13115$

Second ,, $L \times (B+D) = 430 \times (56+30{\cdot}5) = 37195$

The Tables give also the scantlings for bulkheads, masts, rigging, anchors and cables and the general equipment of the ship.

Shipyard workers and draughtsmen refer to the Tables as required and do not attempt to memorise the contents of the fifty-six Tables given in the Regulations, but they may remember from daily experience and repetition work some of the relative dimensions of the more important parts of the structure they are working on.

QUESTIONS.

1. Describe the different stresses a ship is subjected to when she is working in a seaway.

2. What stresses would be experienced when the ship is (*a*) pitching into a head sea; (*b*) rolling heavily in a beam sea?

3. Name the parts of a vessel specially designed to take up (*a*) longitudinal stresses; (*b*) transverse stresses; (*c*) racking stresses.

4. What faulty distribution of cargo would produce (*a*) hogging; (*b*) sagging; (*c*) collapsing stresses?

5. What is meant by "panting"? What parts of the vessel are most subjected to panting and what structural arrangements are made to resist it?

6. Name the several components of (*a*) transverse framing; (*b*) longitudinal framing.

7. Which is the most important item in a vessel's structure, and why?

8. Sketch and describe (*a*) a bar keel; (*b*) a flat plate keel. State why the latter is preferred.

9. What is a "floor?"

10. Show by means of a sketch how a frame, and reversed frame, are connected to a floor plate.

11. Describe any sections, other than frame and reversed frame, used for transverse framing.

12. How are transverse beams connected to the heads of frames?

13. Sketch several forms of beam knees.

14. What is the function of a pillar?

15. Describe a centre plate keelson and state why it is built exceptionally strong.

16. What is a (*a*) a rider plate; (*b*) a foundation plate; (*c*) a lug piece?

17. Show by a sketch how a watertight connection is made between the stringer plate and the shell plating at a weather deck.

18. Are all strakes of shell plating the same thickness; if not, how do they usually vary?

19. What is a McIntyre tank? Show by a sketch its general construction.

20. Why is the cellular double bottom system of construction preferred to the McIntyre system?

21. Sketch a C.D.B. and indicate particularly how watertight connection is made at the bilge.

22. What is (*a*) a longitudinal; (*b*) margin plate; (*c*) tank side bracket; (*d*) gusset plate?

23. What arrangements are made to allow water to flow from one transverse section to the next?

24. When and where are web frames introduced?

25. Show by a sketch the method of uniting a web frame and stringer at their crossing.

26 Show by sketches how two plates are riveted together.

27. Sketch (*a*) a lap joint; (*b*) a butt strap joint.

28. What is zig-zag riveting and chain riveting?

29. Describe with sketches the usual system of shell plating.

30. What are the disadvantages and advantages of the "joggled" and the "out and in" systems?

31. What is the disadvantage of the clinker system of deck plating?

32. What is a stealer?

33. Sketch and name some of the girder sections used in ship construction.

34. Mention the names of different kinds of rivets and illustrate them by sketches.

35. What are the functions of a pillar? What are the structural advantages and the commercial disadvantages of pillars in a cargo hold?

36. Sketch some forms of heads and heels of pillars.

37. How is a deck flat made watertight at the ship's side (*a*) when both frame and reversed frame are severed; (*b*) when the frame is continuous?

38. In what manner do bulkheads contribute structural strength and safety to a vessel?

39. What minimum number of watertight bulkheads is fitted in a steamship and what are their special functions?

40. How is bulkhead plating stiffened and how is it connected to the shell plating?

41. A stringer is cut at a bulkhead, what method is adopted to maintain the strength at the juncture?

42. What is the advantage of having longitudinal bulkheads in cargo spaces?

43. What is a "deep" tank?

44. Describe the special structural arrangements of a deep tank.

45. Can deep tanks be completely filled with water by the same method as D.B. tanks; if not, what may the reason be?

46. The cargo has just been discharged out of a deep tank, describe exactly what should be done before the order is given to fill it with water.

47. What are the structural disadvantages of hatch openings?

48. Describe a method whereby hatch coamings are stiffened and strengthened.

49. How is loss of strength due to cutting transverse beams in way of deck openings restored?

50. What are half beams? How, and to what are their inner ends connected?

51. How is a watertight connection made between a hatch coaming and the deck plating?

52. Sketch an arrangement of portable hatchway beams and fore and afters.

53. In what way do hatch openings affect the seaworthiness of a vessel in bad weather?

54. How is shell plating connected to the stem bar?

55. Describe a method of stiffening the bow of a vessel to resist panting.

56. What are "breasthooks," "crutches," "panting beams?"

57. Sketch the stern frame of a steamship and name its different parts.

58. Where are the transom frame and the transom floor?

59 What are cant frames and cant beams?

60. Sketch the outlines of an elliptical stern and a cruiser stern, and state the advantages and disadvantages of each.

61. Describe a single plate rudder and how it is supported.

62. What takes the weight of the rudder? What is considered to be the angle of maximum steering efficiency and what prevents the rudder going beyond that angle?

63. What is meant by the "centre of pressure" of a rudder and where about is it situated?

64. Describe some forms of rudders and state some of the advantages claimed for them.

65. Describe the stern tube of a steamship and how water is prevented from entering the ship.

66 How is the tail end shaft lubricated?

67. How is a propeller unshipped in dry dock?

68. How is the thrust of the propeller communicated to the ship's hull?

69. Describe the bilge and tank drainage system of a vessel you have served in.

70. Who controls the inlet and outlet valves of tanks and bilges, and where is the valve chest usually placed?

71 What are strum boxes and what precautions must be taken with them?

72. Why are long pipes in a vessel not usually straight throughout their length?

73. How is the depth of water in the various compartments ascertained and who attends to this?

74. What should be done before ballast tanks are run up?

75. What special arrangement is fitted to the air pipes of cargo oil tanks?

76. Describe a system of ventilation adopted in some large passenger ships.

77. How is the stokehold and engine room ventilated?

78. Describe the special features of a vessel constructed on the Isherwood principle.

79. What is corrosion and what parts of the ship are most subject to its effect?

80. How is steel work prepared before coating it with paint?

81. Name some of the paints used at sea and state why different kinds of paint are used for different purposes.

82. What priming coat would you give to (*a*) bare iron or steel; (*b*) new woodwork on deck; (*c*) the funnel.

83. Give a description of any underwater compositions, the preparation of the shell plating and method of applying the bottom coatings when the ship is in dry dock.

84. What is the difference between anti-corrosive, anti-fouling and boot topping compositions, and state why each is used?

85. A butt strap on the shell plating shows signs of leaking. what would you do?

CHAPTER XVIII.

STABILITY, CARGO AND TRIM

LEVERS.

Practical seamanship in many of its branches is an application of some of the elementary principles of mechanics and hydrostatics. Every person when moving his limbs intuitively applies some principle of mechanics either in preserving his equilibrium, overcoming the force of gravity or moving a weight. The human frame is a machine.

Let us refer briefly to some fundamental notions in mechanics.

The **Moment** of a force is its power to cause rotation. The simplest form of schoolroom apparatus for demonstrating the law of moments is a flat wooden ruler graduated in inches, supported on a nail through a hole at its centre so that it is perfectly balanced but free to rotate in the vertical plane about this axis called the **Fulcrum** (*F*).

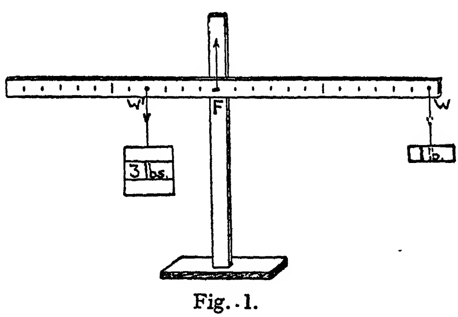


Fig. 1.

When a 1-lb. weight (*W*) is hung at a distance of 12 inches to the right of the fulcrum (*F*), the right hand end of the ruler at once turns clockwise. The weight (*W*) is called the **Force**, and the distance (*F W*) the **Arm**.

The **Moment** of the force round the fulcrum is therefore 12 ins. $\times$1 lb. =12 inch-lbs., or, 1 ft. $\times$1 lb.=1 foot-lbs.

If a weight (W^1) of 3 lbs. be now hung at a distance of 4 inches to the left of the fulcrum *F*, the ruler will turn counter-clockwise and the

moment will be 4 ins.$\times$3 lbs.$=$12 inch-lbs. or 1 foot-lb. The 1 lb. weight will thus be balanced by the 3 lbs. weight and we have what is called a system of **Parallel Forces.** The two forces of 1 lb. and 3 lbs. acting downwards at W and W^1 respectively are balanced by the single, but equal and opposite force, acting upwards at F. The nail at F is supporting a weight of 4 lbs. neglecting the weight of the ruler.

The system is in equilibrium, and all such systems must be so when the sum of the moments on one side of the fulcrum is equal to the sum of the moments on the other side no matter how many weights and distances there may be. The centre of gravity of the system is at the fulcrum F and may be defined as the single force which is equal but opposite to the resultant of the given forces.

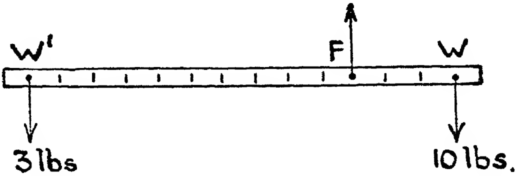


Fig. 2.

Moment$=$power to turn$=$arm$\times$weight.

Example.—If a weight (W) of 10 lbs. is suspended 3 feet from the fulcrum of a freely rotating rod, where must a 3 lbs. weight (W^1) be suspended to regain the equilibrium of the system?

$$\text{Weight } W^1\times FW^1 = \text{weight } W\times FW$$
$$3 \text{ lbs.}\times F\,W^1 = 10 \text{ lbs.}\times 3 \text{ ft.}$$
$$3\,F\,W^1=30 \text{ foot-pounds } \therefore\ F\,W^1=10 \text{ ft.}$$

Ans.—Place the 3 lbs. weight 10 feet on the opposite side of fulcrum to the 10 lbs. weight.

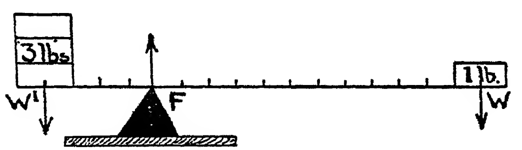


Fig 3.

When the ruler is supported with its centre of gravity over the fulcrum the principle is the same and the 1 lb. weight 12 inches to the right of F will balance the 3 lbs. weight 4 inches to the left of F. We have here a **Lever,** the simplest of machines. There are three kinds

of levers, first, second, and third class. The foregoing illustration is that of a first class lever by simply substituting the term **Power** for one of the weights. The relative positions of the fulcrum, weight and power determine the class of lever.

In levers of the first class the fulcrum is between the weight and the power (Figure 4).

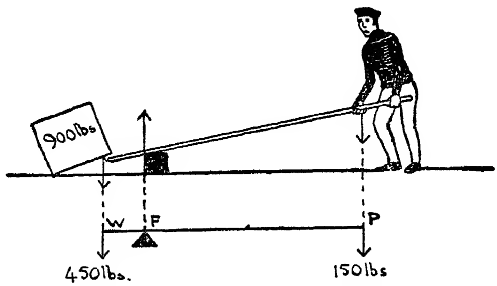


Fig 4 —Lever First Class

Example.—Tilting up a heavy weight to get a cargo sling under it. A man puts his weight of 150 lbs. on the end of a lever 6 feet from the fulcrum, the other end of the lever 2 feet on the other side of the fulcrum is under a box. The man is just able to tip the box, what weight is it?

$$\text{Arm} \times \text{weight} = \text{arm} \times \text{power}$$
$$2\ W = 6 \times 150 \text{ lbs.}$$
$$W = 450 \text{ lbs.}$$

The weight of the box is therefore 900 lbs. as half its weight, 450 lbs., is supported by the corner resting on the floor, and half is supported by the lever.

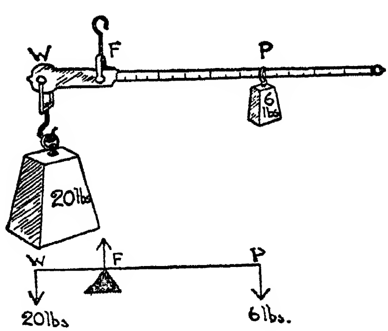


Fig. 5.

Example.—A steelyard. What must be the weight or power of

the bob on a steelyard, if, at a distance of 12 inches from the fulcrum, it balances a weight of 20 lbs. at a distance of $3\frac{3}{5}$ inches from it?

$$\begin{aligned} \text{Arm} \times \text{power} &= \text{arm} \times \text{weight} \\ 12 \times P &= 3\tfrac{3}{5} \times 20 \\ P &= \frac{18}{5} \times \frac{20}{1} \times \frac{1}{12} = 6 \end{aligned}$$

The bob weighs 6 lbs.

In levers of the second class the weight is between the fulcrum and the power (Figure 6).

Example—Find the power exerted by a man pulling upwards on the end of a lever 10 feet long, the other end of the lever is resting on the ground, 3 feet under and beyond the corner of a box, which weighs 500 lbs.

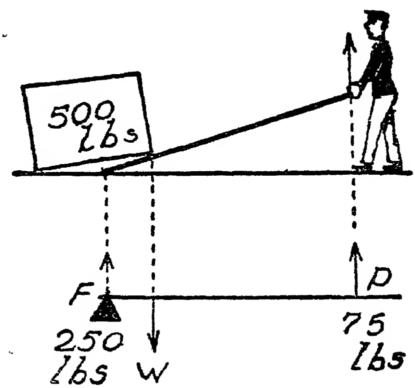


Fig. 6—Lever. Second Class.

Arm $\times$ power $=$ arm $\times$ weight, but half the weight of the box, 250 lbs., is supported on the ground so the man has to lever up 250 lbs. only.

$$\begin{aligned} 10 \text{ ft.} \times P &= 3 \text{ ft.} \times 250 \text{ lbs.} \\ P &= 75 \text{ lbs.} \end{aligned}$$

The man exerts a power of 75 lbs. to tilt the 500 lbs. box.

Example.—An oar 12 feet long rests in a rowlock 4 feet from the loom. Two rowers pull with a power of 100 lbs. each as measured by a spring balance. Required the propelling pressure or weight acting at the rowlock.

The resistance of the water to the movement of the blade is the fulcrum.

$$\text{Arm} \times \text{weight} = \text{arm} \times \text{power}.$$

$$8\ W = 12 \times 100,\ W = 150 \text{ lbs.}$$

The propelling force is 150 lbs. on each rowlock.

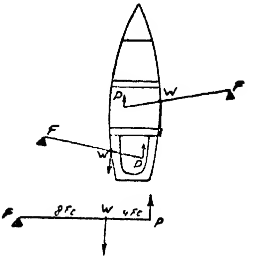


Fig 7.

In levers of the third class the power is between the weight and the fulcrum (Figure 8).

Example.—Up-ending a ladder. The foot of a ladder is fixed to the ground, the other end 30 feet up is leaning on a wall with a pressure

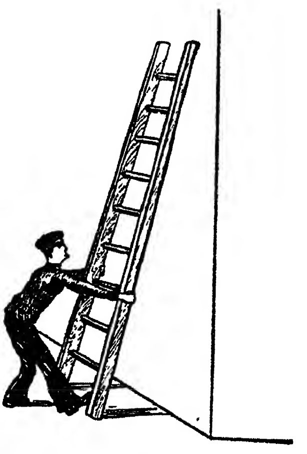


Fig. 8 —Lever. Third Class.

of 10 lbs. A man takes hold of the ladder 5 feet up from the foot; what power must he exert to pull the top end away from the wall?

$$\text{Arm} \times \text{power} = \text{arm} \times \text{weight}$$

$$5\,P = 30 \times 10 \therefore P = 60 \text{ lbs.}$$

The man must exert a pull of 60 lbs.

Parallel Forces and Principle of Moments.

Example.—Two men *A* and *B* are carrying a 10-gallon drum of fresh water on a 6-ft. pole supported on their shoulders. The drum is 2 feet from *A's* shoulder and 4 feet from *B's*. The drum alone weighs 5 lbs., what load is each man supporting?

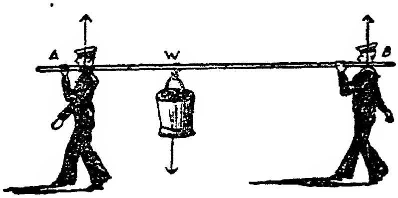


Fig. 9

One gallon F.W.=10 lbs. Total weight of 10 gallons of water and drum is therefore 105 lbs..

If the weight were suspended at the middle of the pole (at 3 feet) the weight would be divided equally between the two men in the proportion as 3 is to 3, the distance of their shoulders from the weight, but the weight is nearer to *A* than to *B* so, obviously, *A's* exertion must be the greater as the forces are balanced, otherwise, something would happen. The exertion is in inverse ratio to the length of the arm of the lever.

$$\frac{\text{Weight borne by } A}{\text{Weight borne by } B}=\frac{\text{distance of } B \text{ from weight}}{\text{distance of } A \text{ from weight}}=\frac{4}{2}=\frac{2}{1}$$

The exertion of *A* is twice that of *B*. Divide the weight into three parts of 35 lbs. each.

Answer.—*B* carries 35 lbs.; *A* carries 70 lbs.

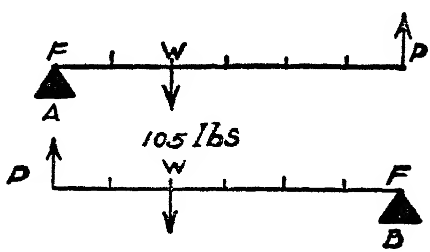


Fig. 10.

We might have applied the principle of moments to this example, using *A's* shoulder as a fulcrum, to find the load carried by *B*.

Arm × power = arm × weight, $6 \times P = 2 \times 105 \therefore P = 35$ lbs.

Conversely, working in the other direction using *B's* shoulder as a fulcrum.

Arm × power = arm × weight $6 \times P = 4 \times 105 \therefore P = 70$ lbs.

Answer.—*B* carries 35 lbs ; *A* carries 70 lbs.

The Wheel and Axle is an application of the law of moments. A dolly winch consists of a wooden barrel of small diameter with a turning handle of larger radius fitted on the end of a spindle through its centre

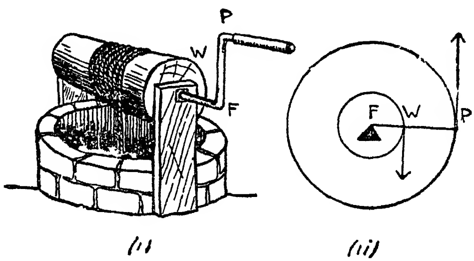


Fig. 11.

as in Figure 11, (i), (ii) being an enlarged end section of the winch. The fulcrum (*F*) is the spindle, *F W* is the radius of the barrel, *F P* is the radius of the circle described by the handle, *W* is the weight to be lifted, *P* is the power applied to the handle.

$$\begin{aligned} \text{Arm} \times \text{weight} &= \text{arm} \times \text{power} \\ \text{or, } F W \times W &= F P \times P \end{aligned}$$

Example.—The radius of the barrel of a hand winch is 6 inches, the radius of the handle is 18 inches, find what weight will be sustained by a force of 100 lbs. applied to the handle.

6 ins. $\times W = 18$ ins. $\times 100$ lbs. $\therefore W = 300$ lbs., the weight which could be held in suspension.

Example.—The radius of a capstan is 1 foot, there are 8 capstan bars each 6 feet long measured from the spindle of the capstan when shipped. A weight of 2 tons is being heaved in on a single wire, find the power to be applied to each bar to hold the weight.

$F P \times P = F W \times W$, or 6 ft. $\times P$ lbs. $= 1$ ft. $\times$ 4480 lbs $\therefore P = 747$ lbs. The power on each bar is therefore $747 \div 8 = 93\frac{3}{8}$ lbs., neglecting friction.

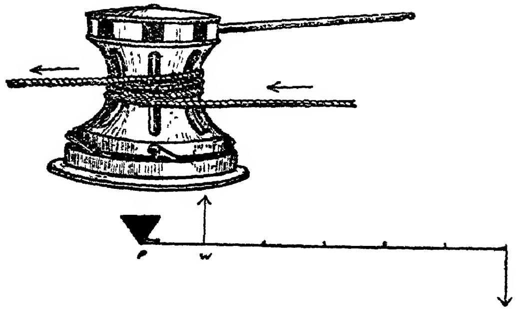


Fig 12.

A Couple — When two equal and opposite forces act at different points on a lever a turning force, called a couple, is introduced which can only be neutralised by another couple tending to produce rotation in the opposite direction.

Examples.—Letting go the handle of the winch when the weight is on, or letting go the capstan bars when the pawls are up; the crank-shaft of a reciprocating steam engine; breasting a ship round the corner of a dock wall, as in Figure 13, where F is the fulcrum, P the power and W

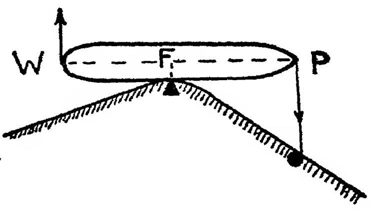


Fig 13.

the weight. In the event of the resistance of the water on the starboard bow and on port quarter being equal to the turning force of P, then the couple would be neutralised and the turning of the vessel arrested.

CENTRE OF GRAVITY OF A SYSTEM OF WEIGHTS.

Example —(1) A wooden batten A B, graduated in feet, is supported at A. A weight of 20 lbs. is suspended at B 8 feet from A. The moment about A is 8 ft. $\times$20 lbs.$=$160 foot-lbs. (Figure 14).

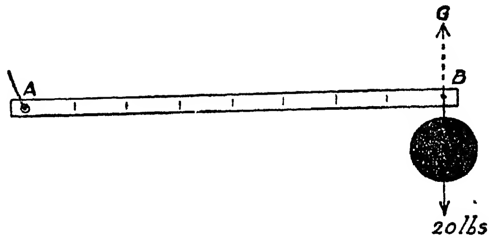


Fig. 14.

The distance of the centre of gravity (C. of G) of the system from A, neglecting the weight of the batten, is $\frac{\text{Moment}}{\text{Weight}}=\frac{160}{20}=8$ feet, which is obvious as the weight B could be suspended in equilibrium by a cord G if the pivot at A were withdrawn.

(ii) **Distribution of Weights.**—Suspend a 10 lb. weight at C 6 feet from A, and another 10 lb. weight at B 8 feet from A. Then moment about A=(6 ft. ×10 lbs.)+(8 ft. ×10 lbs.)=140 foot-lbs. The bending moment at A is now 140 foot-lbs. as against 160 foot-lbs. in example (i), 20 foot-lbs. less, although the total weight suspended by the rod (20 lbs.) is the same, its distribution, however, is different (Figure 15).

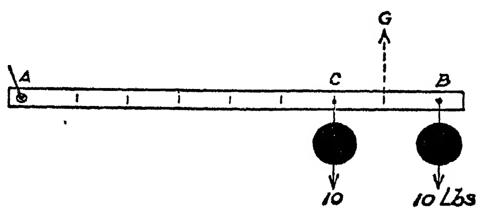


Fig 15.

The C. of G. of the system $=\frac{\text{Moment about } A}{\text{Total weight}}=\frac{140}{20}=7$ feet from A.
and if the pivot at A were removed the system could be balanced in equilibrium at G midway between the two 10 lb. weights, which is obvious when the weight of the rod is neglected.

(iii) **Redistribution of Weights.**—Suspend four 5 lbs. weights at B, C, D and E, points which are 8, 6, 4 and 2 feet from A respectively. The moment about A is now (8×5)+(6×5)+(4×5)+(2×5)=100 foot-lbs.

This demonstrates that the bending moment about A is still further reduced by a redistribution of the total weight of 20 lbs. The C. of G. of the system is $\dfrac{\text{Moment about } A}{\text{Total weight}} = \dfrac{100}{20} = 5$ feet, so that the system could be

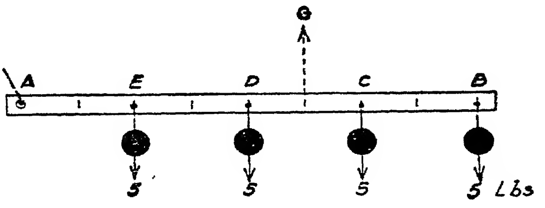


Fig. 16.

balanced at the point G, 5 feet from A. Thus an alteration in the position of the weights alters the position of the centre of gravity neglecting the weight of the batten.

Note that in the foregoing examples the clockwise moment about G is equal and opposite to the anti-clockwise moment about the same point and the rod will not rotate in either direction—it is in equilibrium.

The problem which presents itself on board ship is to find the shift of the centre of gravity from a given position when weights are added to, taken from or moved about in the vessel, the method of solution being the same as in the following co-related examples of a simple rod.

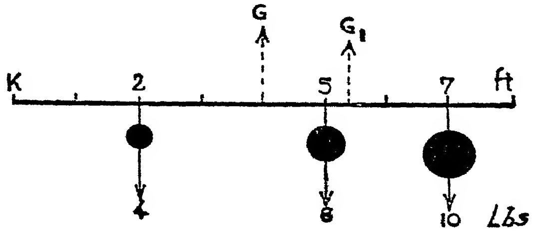


Fig. 17.

Example.—(i) Consider again the case of our 8 ft. stick with its C. of G. at its middle point G when unloaded. If weights of 4, 6 and 10 lbs. be placed 2, 5 and 7 feet respectively from the end K, find the distance point G has shifted.

$$\text{Moment about } K = (2\times4)+(5\times6)+(7\times10)$$
$$= 108 \text{ foot-lbs}$$

$$\text{Distance } K\,G_1 = \frac{\text{Moment}}{\text{Total weight}} = \frac{108}{20} = 5{\cdot}4 \text{ feet}$$

The initial distance $K\,G$ was 4·0 ft.
The new distance $K\,G_1$ is 5·4 ft

$G\,G_1$ = 1·4 ft.

The addition of the weights has shifted the C. of G. 1·4 feet to the right.

(ii) **Redistribution of Weights.**—Suppose the 10 lbs. weight were now shifted 3 feet to the left, find the position of the new centre of gravity.

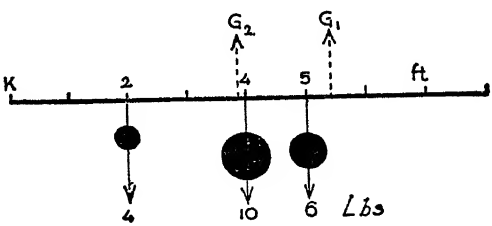


Fig. 18.

Draw Figure 18 for the new condition.

$$\text{Moment about } K = (2\times4)+(4\times10)+(5\times6)$$
$$= 78 \text{ foot-lbs.}$$

$$\text{Distance } K\,G_2 = \frac{\text{Moment}}{\text{Weight}} = \frac{78}{20} = 3{\cdot}9 \text{ feet}$$

$K\,G_1$ was 5·4 feet.
KG_2 is 3·9 „

G_1G_2 is 1·5 „

Shifting the weight 3 feet to the left has shifted the C. of G. 1·5 feet to the left.

(iii) **Lifting off a Weight.**—Lift off the 4 lbs. weight and find the shift of the centre of gravity G_2.

Draw Figure 19 for new condition

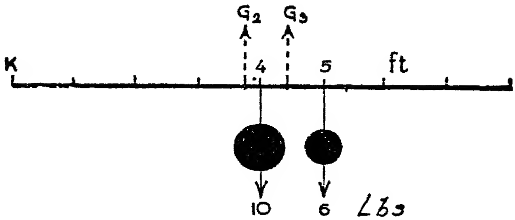


Fig 19

Moment about $K = (4 \times 10) + (5 \times 6) = 70$ foot-lbs.

$$\text{Distance} \quad K\,G_3 = \frac{70}{16} = 4{\cdot}38 \text{ feet}$$

$$\text{,,} \quad K\,G_2 = 3{\cdot}90 \text{ ,,}$$

$$G_2G_3 = {\cdot}48 \text{ ,,}$$

Lifting off the weight has shifted the C. of G. ·48 feet or 5·76 inches to the right.

Note.—Multiply decimals of a foot by 12 to convert into inches.

Example.—(i) Given a rod of negligible weight, loads of 10 lbs. and 5 lbs. are suspended at 2 feet and 8 feet respectively from a point K at one end of the rod. Find the position of the centre of gravity of the system (Figure 20).

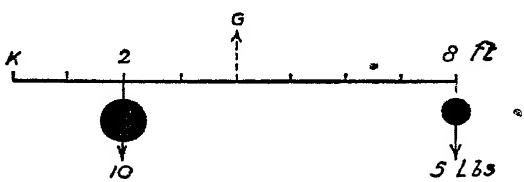


Fig. 20.

Moment about $K = (2 \times 10) + (8 \times 5) = 60$ foot-lbs.

$$\text{Distance} \quad K\,G = \frac{60}{15} = 4 \text{ feet}$$

(ii) **Adding weights.**—A load of 10 lbs. is now suspended 7 feet from K. find the position of the new centre of gravity (Figure 21).

Moment about $K = (2 \times 10) + (7 \times 10) + (8 \times 5)$

,, $= 130$ foot-lbs.

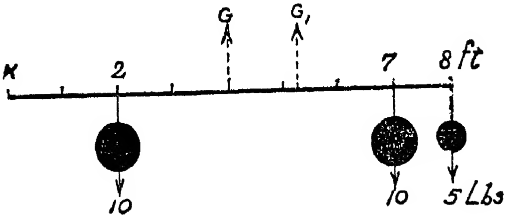


Fig. 21.

$$\text{Distance } K\,G_1 = \frac{130}{25} = 5{\cdot}2 \text{ feet}$$

$$K\,G = 4{\cdot}0 \text{ ,,}$$

$$G\,G_1 = 1{\cdot}2 \text{ ,,}$$

Adding the 10 lbs. weight has shifted the C. of G. of the system 1·2 feet to the right.

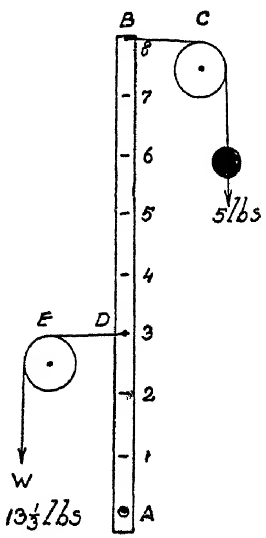


Fig. 22

Example.—A rod of wood AB is pivoted at A so that it revolves freely in a vertical plane. A 5 lbs. weight is suspended at B, 8 feet from A, by means of a string over a frictionless pulley C. What weight must be suspended at D, 3 feet from A, by a string through the pulley E to keep the rod perpendicular?

The left hand moment about A must be made equal to the right hand moment about A to maintain perpendicularity.

Therefore 3 ft. $\times W$=8 ft. $\times$5 lbs.

$3\ W=40 \therefore W=13\frac{1}{3}$ lbs.

Answer.—$13\frac{1}{3}$ lbs.

STABILITY

Equilibrium.—When solid objects are supported at their centre of gravity they are in equilibrium; it may be stable, neutral or unstable equilibrium.

Take an oblong block of wood as in Figure 23. Draw diagonals on one of its faces; their intersection gives the axis of its centre of gravity which, of course, will be situated within the block at its centre. Drive a small tack in the block at the point where the diagonals cross and tie the string of a plumb bob to it.

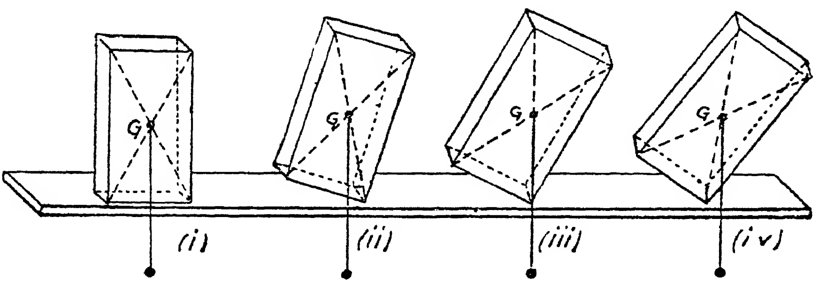


Fig 23.

(i) Stand the block of wood on its end It is in equilibrium and the plumb line bisects the base. The weight of the block acting downwards through its centre of gravity is counteracted by the upward force of the table and being broad of base the block is firmly established in **stable** equilibrium.

(ii) Tilt the block a little to one side. It is supported on one edge, but it is still in **stable** equilibrium because, if the tilting pressure of the hand were removed, it would return to its original upright position as indicated by the plumb line intersecting the base.

(iii) Tilt the block over a little more until the plumb line passes through its corner. The block is then in **neutral** equilibrium, it cannot remain balanced on its edge but will either return to the upright position again or topple over on its side when the hand is removed.

(iv) Tilt it over still further until the plumb line lies outside the base of the block. It will now be in **unstable** equilibrium and will topple over on its side.

The block is in stable equilibrium when the vertical line through its centre of gravity falls within its base, but its equilibrium is unstable

when the vertical line falls outside the base. The broader its base the more stable will the block of wood be The same principle applies to a person who is losing his balance but spreads out his legs to prevent himself from falling by broadening out his base of support.

The equilibrium of a floating ship is somewhat similar but not quite the same owing to the difference in the density of the medium which supports her. The block of wood is supported at the surface of the table, a ship is supported by, but not at the surface of, the water.

Displacement-Tonnage is the weight of the ship and her contents in actual avoirdupois tons

Volume of Displacement is the quantity of water required to fill the moulded shape of the hole left by the ship if she were lifted out of the medium in which she floats. The weight of the water is equal to the weight of the ship, but the volume of the water is only equal to the volume of the underwater portion of the ship. The displacement may be expressed in convertible terms, either in tons weight or in measured capacity.

1 ton fresh water =36 cubic feet
1 ton salt water =35 cubic feet

The displacement tonnage can be found by multiplying the product of the vessel's length, breadth and mean draft by her coefficient of fineness; this gives the volume of displacement in cubic feet, and as there are 35 cubic feet of sea water to a ton, by dividing this volume by 35 we obtain the displacement tonnage, thus:

$$\text{Displacement tonnage in sea water} = \frac{L \times B \times d \times \text{coefficient}}{35}$$

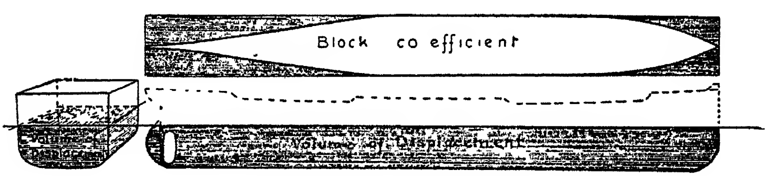


Fig. 24.

Coefficient of Fineness.—The coefficient of fineness of a vessel is the ratio or proportion her underwater form bears to a rectangular shaped block of the same length, breadth and depth (Figure 24).

It will be realised, therefore, that the finer lines a vessel has the

smaller will be her coefficient. In destroyers, yachts and vessels where great speed is required the coefficient may be as small as ·45, whereas in the bluff tramp class where speed is a secondary consideration the coefficient is often as great as ·85. Between these two extremes the coefficient of fineness is adopted to suit the requirements of the vessel.

SHIP STABILITY.

Draw a cross section of a ship with a waterline across it. Mark a spot *G* to represent the **centre of gravity** of the ship which is a point where the whole weight of the ship and her contents are conceived to act vertically downwards. Mark a spot *B* to represent the **centre of buoyancy** of the ship. It is the point at the centre of the displaced volume of water through which the whole supporting force of the water is conceived to act vertically upwards. It will be the geometrical centre of the figure *W L K.*

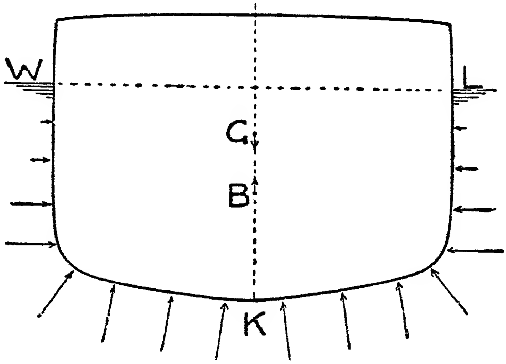


Fig. 25.

The downward force at *G* is equal to the upward force at *B*. They are equal and opposite forces acting in the same vertical line when the ship is at rest. When they are not in the same vertical line something must happen as the ship cannot remain at rest as she wants, automatically, to return to her position of equilibrium. In Figure 25 *K G* is the height of the centre of gravity above the keel, and *K B* the height of the centre of buoyancy above the keel.

(i) **Stable Equilibrium.**—Figure 26 represents the same ship forcibly inclined by an external force such as wind pressure, rolling at sea or by a masthead tackle led ashore somewhere. The centre of gravity is

in the same position as before, because we must assume that nothing in the ship has been shifted as the centre of gravity only moves when weights are moved and, then, in a direction parallel to the direction in which the centre of gravity of the weight has been moved.

K G is the same as in Figure 25, but the centre of buoyancy has moved to the low side of the ship owing to her underwater volume having altered its shape as indicated by the outline of the new *W L K*, so the centre of buoyancy must now be a spot a little to the right of the ship's vertical line at B^1.

The ship's weight, indicated by *W*, acts downwards through *G*, the water buoyancy acts upwards through B^1 and its line of action meets the ship's vertical line at *M*. This spot is called the **metacentre.**

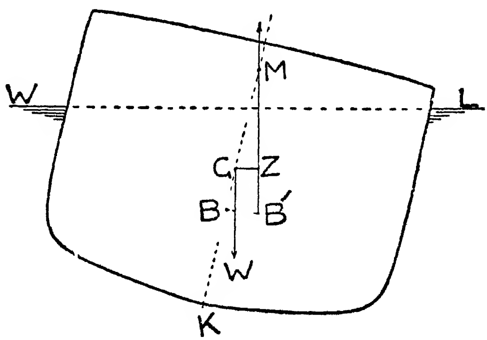


Fig. 26.

The ship at sea oscillates about a rolling axis which is not fixed but is situated in the vicinity of her centre of gravity at a point a little above *G*. The ship, as illustrated in this figure, is said to be in **stable** equilibrium because, when forcibly inclined, she will return to her original upright position when the inclining force is removed. The horizontal distance between the vertical lines through *G* and B^1 increases, within limitations, as the angle of heel increases, this distance being represented by the length of *GZ* in the figure. *GZ* is called the arm and, in this example, a righting lever is being exerted.

The two parallel forces, acting on the lever at the two points *G* and *Z*, form a couple which tends to turn the ship upright again. The moment is, arm $\times$ weight, or, $GZ \times W$, where *GZ* is the horizontal distance between the verticals through *G* and B^1, and *W* is the total weight of the ship. The weight of a ship at any draught can be got from her

Displacement Scale. (See plan of *Caledonian Monarch.*) The arm GZ we shall refer to later in greater detail.

(ii) **Neutral Equilibrium.**—When top weights are placed in the ship so that her centre of gravity is raised gradually and approaches M, the arm GZ gets smaller and smaller and disappears altogether when G coincides with M. The downward force through G and the upward force through B^1 are then acting in the same vertical line; the lever has disappeared and the ship is now in a condition of **neutral** equilibrium.

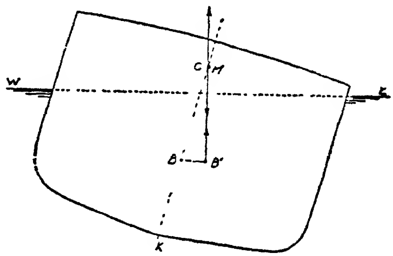


Fig. 27.

(iii) **Unstable Equilibrium.**—When the point G is above the metacentre we have the condition of **unstable** equilibrium and the arm GZ operates a capsizing moment. The ship will heel over further and may probably capsize.

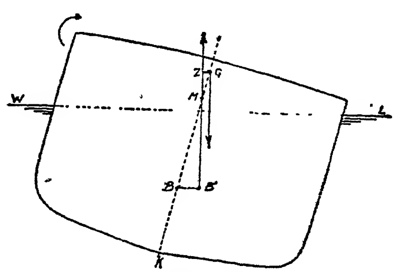


Fig. 28.

The illustrations show that a ship is in (i) stable equilibrium when G is below M, a positive GM; (ii) neutral equilibrium when G coincides with M; and (iii) unstable equilibrium when G is above M, a negative GM.

The foregoing principle of stability applies to small angles of heel and is referred to as **initial stability,** which is the resistance offered by

the ship to small inclinations, and assumes that the line of action through the centre of buoyancy passes through the metacentre. This is practically so for small angles not exceeding 12 degrees, but may not be the case at bigger angles in a ship-shaped body.

Metacentric Height.—We must know, in the metacentric system of stability, the positions G and M relatively to the keel, or, at least, the distance between them which is called the *metacentric height* (GM); also the angle of heel, called θ, and the weight of displacement of the ship. The height of the metacentre is assumed to be constant at a given draught, but the position of the centre of gravity moves up and down when weights in the ship are raised and lowered with a consequent decrease and increase in her GM. The arm GZ becomes smaller with every reduction in the distance GM, and the length of this arm, as we have been endeavouring to point out, is a determining factor in the law of moments.

The metacentre acting through Z is the fulcrum, the ship's displacement acting through G is the power or weight, and, as before, arm $\times$ power $=$ moment, or, $GZ \times W =$ foot-tons and expresses the energy of the ship to return to a position of equilibrium.

Example.—If $GZ = 2$ feet and weight of ship $= 5000$ tons, the moment will be $2 \times 5000 = 10{,}000$ foot-tons. This is equivalent to a 1 ton weight suspended at the end of a lever 10,000 feet, nearly 2 miles, long, or, of 10,000 tons weight at the end of a lever 1 foot long.

When weights are kept low the GM and GZ are big and the ship is said to be **stiff**, she is hard to incline, but when forcibly heeled over an excessive righting moment is brought into operation which brings the ship upright in a violent manner, making the motion uncomfortable for those on board and straining the hull unnecessarily. Should the weights be high so that GM and GZ become very small the ship is said to be **tender**, she is easily heeled over and is slow and sluggish in returning to the upright. She would be quite a comfortable ship at sea if she did not capsize. The cargo when being loaded should be distributed to produce a condition between these extremes so that the ship will be of good behaviour at sea. In theory this is quite simple; in practice, however, it is more complicated.

The metacentric height (GM) is found by actually heeling the ship in her **light condition**, that is, with no ballast, cargo, bunker coal, stores or water on board—just the completed ship with steam up. This initial GM having been supplied by the builder, also the corresponding

heights of the centre of gravity and of metacentre above the keel, provide information which offers a starting off point from which the GM for various conditions of loading may be computed.

THE HEELING EXPERIMENT TO FIND GM.

The displacement of the ship is carefully calculated by the builders by adding up the weights of all the materials in her construction and of stores, equipment and any ballast or cargo that may be on board at the time. Let us assume a displacement of 2000 tons; the ship should be upright, loosely moored by the head and stern, absolutely free to incline and the weather should be calm

(i) A known weight, say 10 tons, is placed exactly in the middle line of the vessel (56-lb. weights are convenient to handle and are uniform in shape). A cord is fixed to a hatch coaming with a plumb bob attached to its lower end reaching down into a hold and free to pendulate across the face of a batten fixed athwartship and divided into fractions of an inch. The initial position of the cord PQ on the scale is carefully noted.

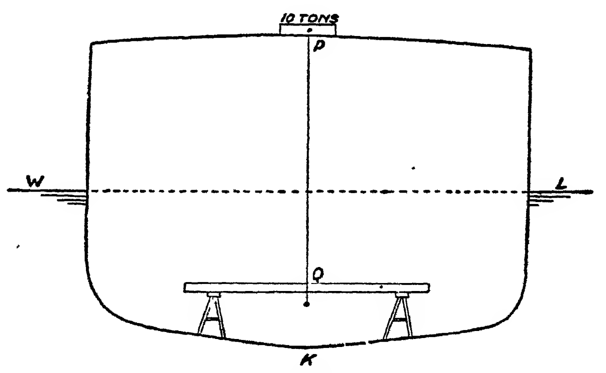


Fig. 29.

(ii) The 10-ton weight is then shifted from the middle line to one side of the ship and the exact distance the centre of the weight has been moved transversely is accurately measured, say 20 feet. This gives a "shift" moment of 10 tons$\times$20 feet$=$200 foot-tons, or, in general terms, $w\times d$=shift moment, where w is the weight and d the distance it has been moved athwartships.

The distance, RQ in Figure 30, through which the plumb line has

moved is measured on the batten, also its perpendicular length PQ This gives two sides of the right angled triangle PQR from which $\angle P$, usually called θ, can be found. Suppose $RQ = 12$ inches and $PQ = 20$ feet then cotangent $\theta = \dfrac{PQ}{RQ} = \dfrac{240 \text{ ins}}{12 \text{ ins}} = 20 \therefore \theta = 2° 52'$ (from *Norie's Nautical Tables*).

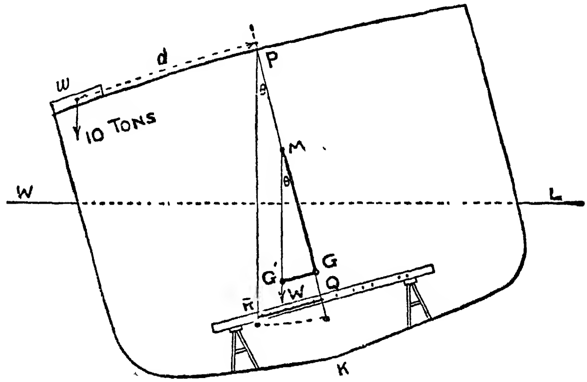


Fig. 30.

The 10-ton weight may then be shifted over to the other side of the ship and the experiment repeated as a check on the first trial. The angle of heel is greatly exaggerated in the figure to open out the angle θ.

(iii) The following deduction is then made. It is required to find the distance between G and M, the positions of which are not yet known. But G actually moves to G_1 in a direction parallel to that of the weight and is therefore parallel to QR; G_1M is parallel to RP and $\angle M = \angle P = \angle \theta$ so that triangles PQR and MGG_1 are similar.

The ship is in equilibrium so her centre of gravity must be in the same vertical line as her centre of buoyancy and M, by definition, must be the metacentre.

The shift moment of G is proportional to the shift moment of w, that is $GG_1 \times W = d \times w$ from which $GG_1 = \dfrac{d \times w}{W}$ . . . Equation (1)

where GG_1 is the transverse shift of G

W the ship's displacement in tons

d the distance through which the weight w has been moved

But $G M = G G_1 \cot \theta$, and by substituting Equation (1) for $G G_1$ we get $G M = \frac{d \times w}{W} \cot \theta$, which is the general equation to find the initial $G M$

The information may be written in the form of a question. Given ship's displacement during the inclining experiment 2000 tons; weight of 10 tons moved transversely across the deck 20 feet; length of plumb line 20 feet; deflection of plumb bob 12 inches. Required the $G M$—

$$\text{Equation:—} G M = \frac{d \times w}{W} \cot \theta = \frac{240 \text{ ins.} \times 10 \text{ tons} \times 240 \text{ ins.}}{2000 \text{ tons} \times 12 \text{ ins.}} = 24 \text{ ins}$$

The metacentric height is 2 feet.

This brief description indicates in general terms the principle of the inclining experiment, but various adjustments have to be made before the $G M$ corresponding to the actual light condition of the ship can be ascertained, because the experiment only determines the $G M$ for the particular condition of the ship at the time, and the effect of additional weights on board and of those yet to come have to be allowed for.

Example.—In a vessel of 4000 tons displacement it was found desirable to lower the existing centre of gravity which was 18 feet above the keel. A tank was filled with 300 tons of water, its centre of gravity being 2 feet above the keel. Required the new vertical centre of gravity.

$$G G_1 = \frac{w \times d}{W}$$

Where $G G_1$ is the shift of G

w the weight of water in the tank, 300 tons

d the vertical distance between the centres of gravity of ship and tank

W the displacement after the tank is filled

$$G G_1 = \frac{300 \text{ tons} \times 16 \text{ feet}}{4300 \text{ tons}} = 1 \cdot 1 \text{ feet}$$

The new V.C.G. is $18 - 1 \cdot 1 = 16 \cdot 9$ feet above keel.

GRAPHS.

Various graphs and curves are used by ship designers by which irregular areas, positions of centres of gravity and of buoyancy and other variable elements may be co-ordinated. It is the business of the shipbuilder to ascertain from the plans of the ship the information

necessary for drawing such curves and it is the duty of the ship's officer to be able to read them intelligently.

We shall illustrate five curves which are associated with the loading of a ship, viz., curves of displacement, tons per inch immersion, stability, buoyancy and metacentre.

Displacement and Tons per Inch Curves.—The scale of feet at the side of Figure 31 is a scale of draughts and against each even foot is the displacement (weight of ship+bunkers and cargo) given in tons, the displacement in F.W. is given to the left of the draught scale and for S.W. to the right.

The light load line is 8 feet and at this draught the displacement of the ship is 3500 tons in F.W. and 3600 tons in S.W.

The load line draught is 20 feet in S.W. and the corresponding displacement is 10,100 tons. The deadweight or carrying power of the ship is (10,100−3600)=6500 tons when loading in S.W. The tonnage at intermediate draughts can be found by simple proportion, but ship draughtsmen dearly love a curve although the two shown here are nearly straight.

The vertical lines (ordinates) represent draughts, the horizontal lines (abscissae) indicate a scale of displacement at the bottom and a scale of tons per inch immersion at the top, the two curves having been drawn on the same sectional paper for convenience.

Example.—Required (*a*) the displacement and (*b*) the tons per inch at 12 feet draught.

(*a*) Find 12 feet on the draught scale and trace along the horizontal line until the displacement curve is reached, then move vertically downwards to the bottom scale and read the displacement in tons. It is a little less than 5600 tons, say about 5570 tons.

(*b*) Continue along the 12 feet line to the T.P.I. curve, then move vertically upwards and read the T.P.I. which is a little more than 42½, say 43 tons per inch.

Example.—Required the displacement and tons per inch at a draught of 17 ft. 6 ins.

Answer.—Displacement 8600 tons. T.P.I. 48 tons.

Curves seldom give results as accurate as the information they are derived from, and usually on board ship any information desired is read from the scale, interpolating between the even feet when necessary.

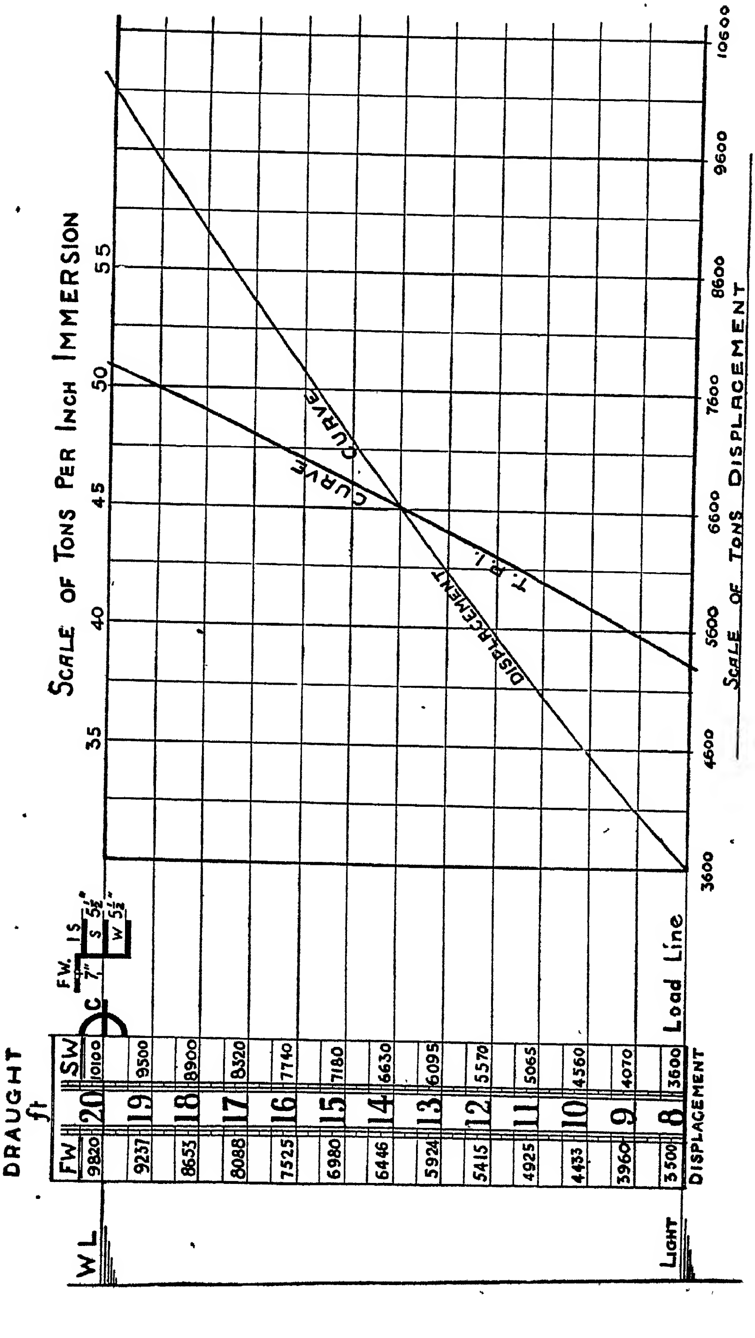

Scale of Tons Per Inch Immersion
35
40
45
50
55
Scale of Tons Displacement
3600
4600
5600
6600
7600
8600
9600
10600
Curve
Displacement Curve
T. P. I.
DRAUGHT ft
FW
SW
9820 20 10100
9237 19 9500
8653 18 8900
8088 17 8320
7525 16 7740
6980 15 7180
6446 14 6630
5924 13 6095
5415 12 5570
4925 11 5065
4453 10 4560
3960 9 4070
3500 8 3600
DISPLACEMENT
C
FW.
IS
S
W
7"
5½"
5½"
Load Line
WL
Light

Fig. 31.

For example, the displacement given

at 17 feet is			8320 tons	
at 18 ,,			8900 ,,	
Difference in		12 ins.	580 ,,	Diff. for 1 in. is 48·3 T.P.I
,,		6 ins.	290 ,,	
add for	17 ft.	0 ,,	8320 ,,	
Displacement at	17	6	8610 ,,	
,,	8	0	3600 ,,	From Displacement Scale.
Deadweight in S.W.			5010 tons, at a draught of 17 ft. 6 ins.	

CURVE OF STABILITY

A curve of stability is one which shows graphically the relative leverages exerted by the ship to restore herself to a position of equilibrium when she has been forcibly inclined by the wind or sea. The reading of this curve calls for a general understanding of the principles of stability as already explained.

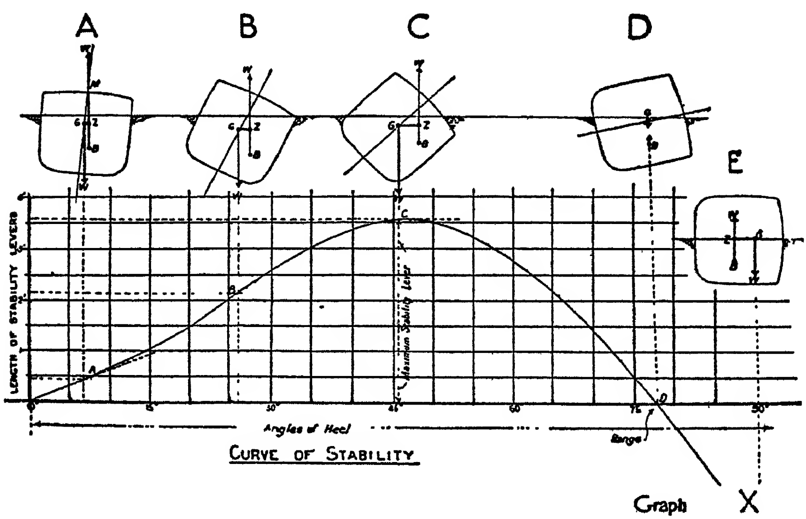


Fig. 32.

The figures of the inclined ship show a vessel at different angles of heel and in each case *G* represents the centre of gravity of the ship

which is a fixed position unless the weights in the ship are altered. The whole weight of the ship acts vertically downwards through G as represented by $G\,W$.

B is the centre of buoyancy of the ship and is the centre of the volume of the water displaced. It changes its position along with the change in shape of the underwater form of the ship. The total upward pressure of the water, which is equal to the whole weight of the ship, acts vertically upwards through B in the direction $B\,W$.

In the successive figures A, B and C the righting arm GZ is progressively increased, and the ship has an increasing tendency to return to an upright position. But in figure D the GZ has disappeared, the ship is in neutral equilibrium, she is inert and cannot by her own effort return to an upright position. Figure E illustrates the ship in a position of unstable equilibrium, because it will be seen that the downward force through G and the upward force through B have conspired to produce a lever GZ which will capsize the ship.

The abscissa is a scale of degrees to represent angles of heel of the ship and the ordinate is a scale of feet to represent the length of GZ the righting arm.

To Read the Stability Curve—Fig. A represents the ship heeled to an angle of 7°. Find 7° on the horizontal scale, move vertically upwards to the curve at A, then horizontally to the left and read off the length of GZ from the scale. The righting arm or lever is $5\frac{1}{2}$ inches long, or ·45 feet. If the weight of the ship were 5000 tons, then the turning power exerted by the ship to bring herself to an upright position is 5000 tons $\times$·45 feet$=$2250 foot-tons.

Figure B represents a heel of 26°. The length of GZ from the curve is 2·2 feet, the moment, or turning power, would be 5000 tons$\times$2·2 feet$=$11,000 foot-tons.

Figure C represents a heel of 46°, the length of GZ from the curve is about 3·6 feet, the righting moment would be 5000 tons$\times$3·6 feet $=$18,000 foot-tons. This is the position of maximum effort, for it will be seen that as the angles of heel increase beyond 45° the ship becomes more reluctant to return to the upright as evidenced by the diminishing lengths of the righting arms and, at an angle of about 78°, GZ disappears and the "range" of the stability curve is complete, for on heeling beyond 78° the ship will capsize if left to herself.

METACENTRIC DIAGRAM AND CURVE OF BUOYANCY.

Sometimes, but very rarely, curves of metacentres and of centres of buoyancy are supplied by the builder They give the heights of the metacentre and the centre of buoyancy above the keel as calculated for various draughts by the ship designer.

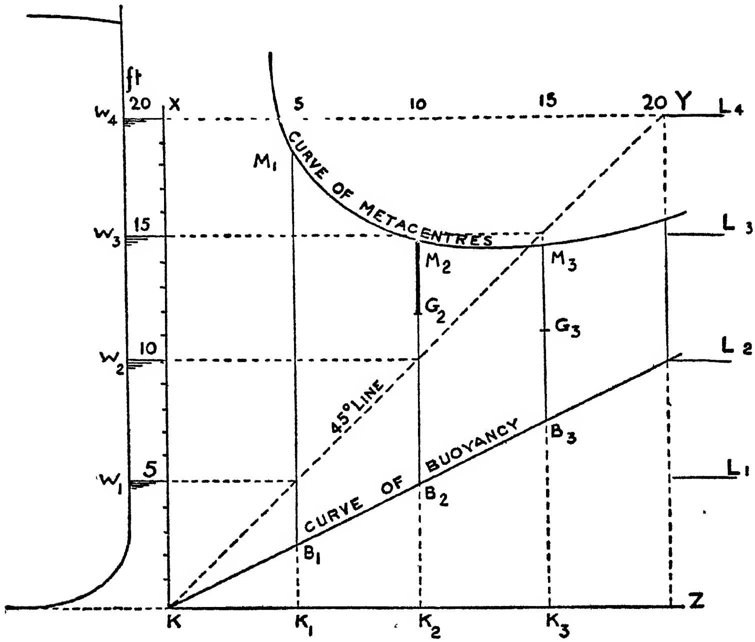


Fig. 33.

The vertical scale and the horizontal scale in the figure are equal and represent the draught of the ship. The diagonal line KY is drawn at an angle of 45° for convenience in plotting so that the figure $K\,X\,Y\,Z$ is a square.

The heights of the centres of buoyancy for a series of draughts having been calculated are plotted as B_1, B_2, B_3, etc., and a curve, which is almost straight, is drawn through the spots.

Thus $K_1\,B_1$	is the V.C.B. for	5	feet draught
$K_2\,B_2$	,,	10	,,
$K_3\,B_3$	,,	15	,,

The heights of the metacentres above the keel ($K\,M$) are also

calculated and plotted on their respective ordinates, and the curve of metacentres, which is a bold curve, drawn through the spots.

Thus $K_1 M_1$ is the height of the metacentre for ·5 feet draught
$K_2 M_2$ „ „ 10 „
$K_3 M_3$ „ „ 15 „

The vertical distance between the curves gives the BM at any desired draught.

Thus $B_1 M_1$ is the BM for a draught of 5 feet
$B_2 M_2$ „ 10 „
$B_3 M_3$ „ 15 „

A graph for centres of gravity is never given as the V.C.G. alters with every re-distribution of the weights in the ship, but if the height of the C. of G. above the keel (KG) is given for certain definite conditions of loading then those spots could also be plotted on the metacentric diagram and the GM recorded for at least those particular conditions. This information is usually worked out for (1) the light load line condition; (2) with water ballast tanks filled and a particular quantity and distribution of bunkers on board.

Example.—The ship's centre of gravity for the light condition at a mean draught of 10 feet is computed to be 12 feet above the keel. Required the metacentric height from the diagram.

Find the 10 feet draught on the horizontal scale; it is at K_2. Measure $K_2 G_2$ 12 feet upwards and this gives the position of the C. of G. The vertical distance $G_2 M_2$ is the metacentric height required. It measures 3 feet from the scale.

Example.—The C. of G. with ballast tanks and bunkers filled is computed to be 11 feet above the keel at a mean draught of 15 feet. Required the GM.

Find the 15 feet draught on the horizontal scale and measure the height of the metacentre above the keel; it is

$K_3 M_3$ = 14 ft. 6 ins.
$K_3 G_3$ = 11 ft. 0 ins.
$G_3 M_3$ = 3 ft. 6 ins. the metacentric height required

CARGO AND STABILITY.

It was pointed out on page 506 that the height of the initial centre of gravity and of metacentre above the keel for the ship in her light load line condition is supplied by the builder and that this information offers a starting off point from which the GM for other conditions of

loading may be computed. The procedure is to consult the cargo plan and ascertain the height of the centre of gravity above the keel ($K\ G$) of each superimposed block of cargo and also its weight. The position of the centre of gravity (V.C.G.) will be approximately near the middle line of the block of cargo when it is of equal density throughout. A simple example will perhaps indicate the principle.

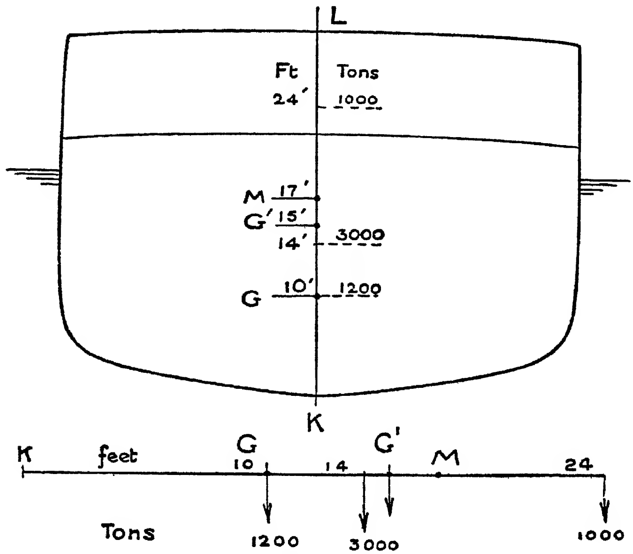


Fig. 34.

Example.—A vessel's light displacement is 1200 tons and initial centre of gravity 10 feet above the keel ($K\ G$). She loads 3000 tons of coal in her lower holds, the estimated centre of gravity being 14 feet; and 1000 tons in her 'tween decks, the centre of gravity being 24 feet. If her metacentre at load draught is 17 feet above keel (KM), required her $G\ M$ when loaded.

	Tons	V.C.G.	Moment (foot-tons)
Coal	3000	14 ft.	42,000
,,	1000	24 ft.	24,000
Ship	1200	10	12,000
	5200		78,000

$$\text{The new C. of G. above } K = \frac{\text{moment}}{\text{weight}} = \frac{78{,}000}{5200} = 15 \text{ feet}$$

$K\,G^1$ after loading is	15 feet	
$K\,M$,,	17 ,,	
$G^1\,M$,,	2 ,,	

The figure indicates the positions of the weights and of G and M relatively to the keel.

In order to associate the idea of the system of cargo weights with our previous examples of simple systems of moments on a wooden rod, we could turn the ship, as illustrated, on her side and by conceiving $K\,L$ to represent a horizontal rod with the weights suspended at their respective distances from K the new centre of gravity can be determined in exactly the same way by summing up the moments about K.

Example.—The displacement of a ship in light condition is 3250 tons, centre of gravity 20 feet above keel, metacentre 22 feet above keel. Cargo is then loaded as follows:—

Weight of cargo—Tons	1000	1500	1250	1100	900	600	400
V.C.G. above keel—Feet	24	22	21	19	23	25	18

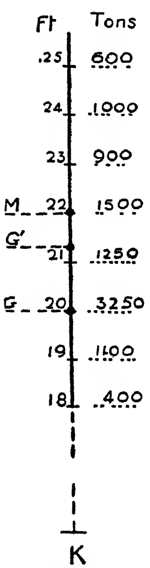


Fig. 35.

Find the new metacentric height assuming $K\,M$ to be the same.

Arrange the work as follows.

Weights	V.C.G.	Moments
400 tons	18 feet	7200
1100 ,,	19 ,,	20,900
G 3250 ,,	20 ,,	65,000
1250 ,,	21 ,,	26,250
1500 ,,	22 ,,	33,000
900 ,,	23 ,,	20,700
1000 ,,	24 ,,	24,000
600 ,,	25 ,,	15,000
10,000		212,050

$$K\,G^1 = \frac{\text{moment}}{\text{weight}} = \frac{212{,}050}{10{,}000} = 21{\cdot}2 \text{ feet}$$

$K\,G^1$ when loaded $= 21{\cdot}2$ feet

$K\,M$,, $= 22{\cdot}0$ feet

$G^1\,M$ $= 0{\cdot}8$ feet $= 9{\cdot}6$ inches

At the first port of call the following cargo was discharged. Find the new $G\,M$ assuming $K\,M$ to remain the same.

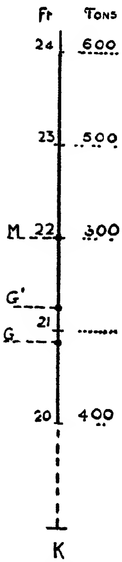


Fig. 36.

Weight of cargo—Tons	400	300	500	600
V.C G. above keel—Feet	20	22	23	24

	Weights	V.C.G.	Moments
	400 tons	20 feet	8000
	300 ,,	22 ,,	6600
	500 ,,	23 ,,	11,500
	600 ,,	24 ,,	14,400
Removed	1800 tons		40,500 foot-tons
From	10,000 ,,		212,050 ,,
Remaining	8200 ,,		171,550

$$K\,G^1 = \frac{171{,}550}{8200} = 20{\cdot}9 \text{ feet}$$

$K\,G^1$ for new condition $= 20{\cdot}9$ feet
$K\,M$,, $= 22{\cdot}0$,,
$G^1\,M$,, $= 1{\cdot}1$,,

CARGO PLAN.

Cargo plan (Figure 37) is that of a vessel laden with a cargo from U.S.A. Given the following information calculate the vessel's meta-

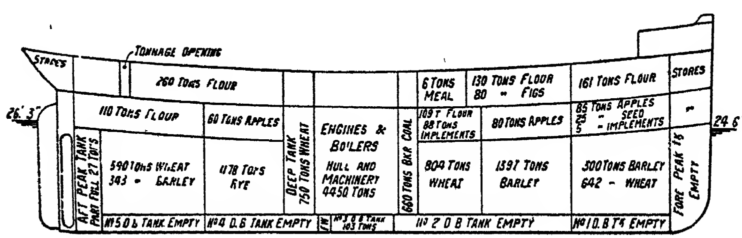


Fig. 37.

centric height. Light displacement 4450 tons, height above keel of initial centre of gravity13 feet ($K\,G$); the height of metacentre in load condition 18 feet (KM).

Compartment		Contents	Tons	V C G.	Moments (Foot-tons)
				feet	
No. 1.	Lower	Barley & wheat	942	14	13188
	'Tween deck	Apples seed, etc	115	26	2990
	Shelter deck	Flour	161	32	5152
No 2.	Lower	Barley	1397	14	19558
	'Tween deck	Apples, etc.	80	25	2000
	Shelter deck	Flour, figs	210	31	6510
No 3.	Lower	Wheat	804	14	11256
	'Tween deck	Flour, etc.	197	25	4925
	Shelter deck	Meal	6	31	186
	Deep tank	Wheat	750	16	12000
No 4.	Lower	Rye	1178	14	16492
	'Tween deck	Apples	60	25	1500
	Shelter deck	Flour	260	31	8060
No 5	Lower	Wheat	933	16	14928
	'Tween deck	Barley	110	26	2860
	Cross bunker	Coal	660	16	10560
No 3	D B. tank	Fuel	103	2	206
	After peak tank	Water	27	12	324
	Ship	C of B.	4450	13	57850
			12443		190545

$$KG^1 = \frac{\text{moment}}{\text{tons}} = \frac{190545}{12443} = 15{\cdot}3 \text{ feet}$$

$$KM = 18\ 0$$

$$\text{new } GM = 2{\cdot}7$$

We have computed the moment for each weight but, obviously, those having their centres of gravity at the same height above the keel could be slumped together and so reduce the number of items.

CARGO AND TRIM.

The ship supported as she is by fluid pressure is free to incline in any direction under the action of forces. The forces acting on the ship and the effects produced when dealing with inclinations in a fore-and-aft direction are similar to those just described for transverse inclinations. In Figure 38 B denotes the longitudinal position of the centre of buoyancy (L.C.B.) and G the longitudinal position of the centre of gravity (L.C.G.). It should be observed that in any vessel the longitudinal metacentric height (L.G.M.) is considerably greater than the transverse metacentric height (GM) and consequently the ship is very much stiffer in a fore-and-aft direction than transversely. The ship will always be stable in a fore-and-aft direction as it is practically impossible to raise the C. of G. above the longitudinal metacentre.

The height of the metacentre above the centre of buoyancy is

$$BM = \frac{L^2}{12\,D}$$

Where L is the ship's length and D the draught for box-shaped vessels.

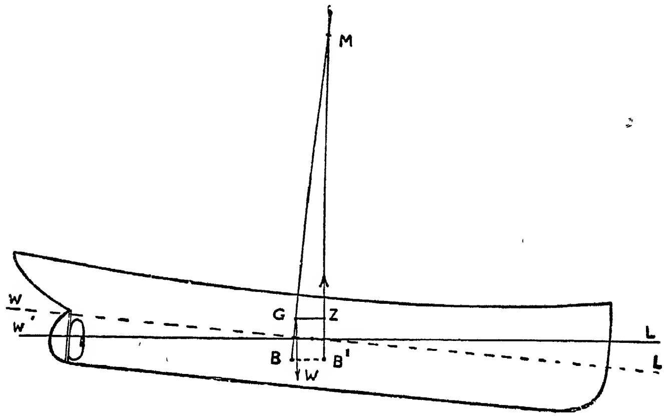


Fig. 38.

Figure 38 represents a ship tipped by the head by some external force. B moves to B^1 but the C. of G remains at G as no alteration has been made in the distribution of weights in the ship. M is the point where the vertical line through the new C. of B. intersects the vertical line through the original C. of B. and this defines the longitudinal metacentre. GZ is the arm of the moment tending to bring the ship back to an even keel and, as in the case of transverse inclinations, the moment will be $W \times GZ$.

The draught of a ship is given at the stem and stern and there seems no particular reason why it should not also be given amidships. The draught figures are 6 inches in depth and the space between them is also 6 inches.

When the draught is greater at one end than the other the ship is said to be **trimmed** so much by the head, or by the stern, as the case may be.

The **tipping centre** is assumed to be at the middle of the vessel's length for approximate calculations involving small changes of trim.

If a weight (w), say 90 tons, be placed exactly over the tipping centre (T.C.) the ship will sink bodily and, if her **tons per inch immersion**

at this draught be 30 tons, the sinkage would be 3 inches forward and 3 inches aft, thus increasing her mean draught 3 inches.

But if the weight (w), 90 tons, were placed 100 feet before the tipping centre the vessel would trim by the head and the ship's waterline $W\ L$ would be changed to $W^1\ L^1$, showing a wedge of immersion forward

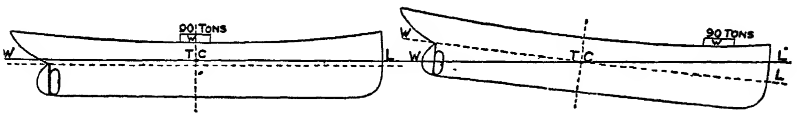


Fig. 39.

and a wedge of emersion aft as in Figure 39. Conversely, if the weight were placed aft the ship would trim by the stern. In order to compute the change of trim we must know:—

(1) The weight required to alter the mean draught 1 inch, that is the "tons per inch immersion," abbreviated to T.P.I. (get used to these abbreviations as they save a lot of writing). This quantity varies slightly with change of draught owing to the altering shape of the underwater form of the ship.

The T.P.I. can be got from the displacement scale.

(2) The **Moment to Alter Trim by 1 Inch**, or **Inch-Trim-Moment**, abbreviated to I.T.M. This information should be supplied by the builders as it is determined by calculation or by experiment, and it also varies with the draught.

The following formula gives an approximate inch-trim-moment.

$$\text{I.T.M.} = \frac{30T^2}{B}$$

where T = tons per inch immersion as found from the Displacement Scale
B = moulded breadth of vessel

(3) The weight added to, discharged from, or moved about in the ship and the longitudinal distance of its centre of gravity from the tipping centre must also be known; then weight × distance = moment.

Knowing the T.P.I. and the I.T.M. the method of computing the change of trim may perhaps be best demonstrated by means of an example.

Example.—Given T.P I. 40 tons, I.T.M. 1500 foot-tons, draught 12 ft. 00 ins. forward, 14 ft. 00 ins. aft. The after peak tank, 180 feet

from tipping centre, is then filled with 40 tons water. Requred the new draught.

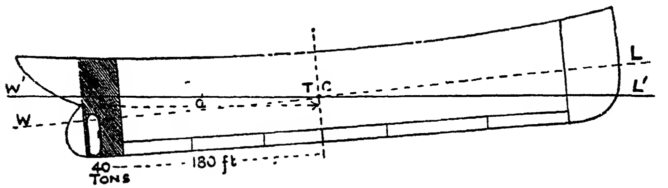


Fig 40.

$$\text{Mean sinkage} = \frac{\text{tons}}{\text{T.P.I.}} = \frac{40}{40} = 1 \text{ inch}$$

$$\text{Total trim} = \frac{\text{total moment}}{\text{I.T.M.}} = \frac{180 \times 40}{1500} = \frac{72}{15} = 4 \cdot 8 \text{ ins.}$$

$$\text{Half trim} = 2 \cdot 4 \text{ ins.}$$

	Forward		Aft.	
	ft.	ins.	ft.	ins.
Original draught	12	00	14	00
Mean sinkage		1		1
	12	01	14	01
Half trim	—	2·4	+	2·4
Final draught	11	10·6	14	03·4

Half the total trim is allocated to each end.

Example.—Given T.P.I. 53. tons, I.T.M. 1423 foot-tons. Find the effect of adding 100 tons to No. 1 hold 150 feet forward of the tipping centre.

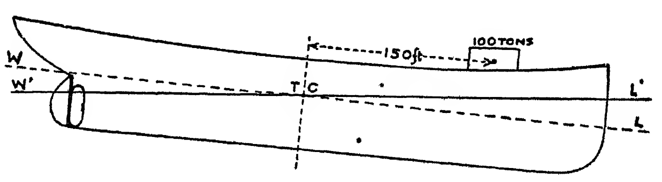


Fig. 41

$$\text{Change of mean draught} = \frac{\text{tons}}{\text{T P I.}} = \frac{100}{53} = 1{\cdot}89 \text{ inches}$$

$$\text{Total trim} = \frac{\text{total moment}}{\text{I.T.M.}} = \frac{150 \times 100}{1423} = 10{\cdot}5 \text{ inches}$$

Half the total trim is allocated to each end of the ship so that she will go down $5\frac{1}{4}$ ins. forward and rise $5\frac{1}{4}$ ins. aft and increase her mean draught 1·89 inches.

A rough approximation of the I T M. may be found when one has a ship to experiment with by noting very carefully the ship's draught, then running up a double bottom tank, and again carefully noting the new draught. The weight of water in the tank can be got from the ship's displacement scale and the distance of its centre of gravity from the tipping centre measured from the profile plan.

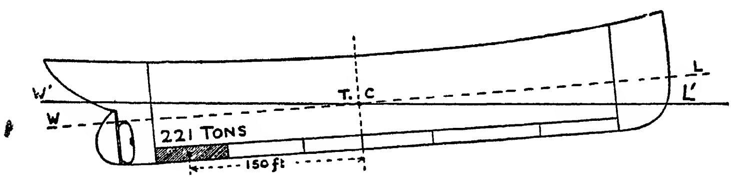


Fig. 42.

Example.—The centre of gravity of No. 6 D.B. tank is 150 feet abaft the tipping centre and contains 221 tons water.

	ft.	ins.		ft.	ins.	
Draught before filling	12	06	F	12	06	A
Draught after filling	11	06		13	06	
	− 1	00		+ 1	00	

The total alteration of trim is therefore 24 inches.

$$\text{Total trim} = \frac{\text{total moment}}{\text{I.T.M.}} \text{ or,} \quad 24 \text{ ins.} = \frac{150 \text{ ft.} \times 221 \text{ tons}}{\text{I.T.M.}}$$

$$\text{I.T M.} = 150 \times 221 \div 24 = 1381 \text{ foot-tons.}$$

The I.T.M.=1381 foot-tons, a quantity which would yield, theoretically, answers approximately correct for that particular draught.

Example.—The draught of a ship on arrival at a port of call will be 22 ft. 01 ins. forward, 24 ft. 10 ins. aft, when cargo will be discharged as follows: T.P.I. 53 tons; I.T.M. 1423 foot-tons, what will her draught be then ?

From hold	Tons	Distance from T.C.	Moment in foot-tons
No. 1	500	150 F.	75000 Ford.
2	67	88 F.	5896 ,,
3	125	23 F.	2875 ,,
4	370	100 A.	37000 Aft
5	150	152 A.	22800 Aft.
	1212		83771 Ford.
			59800 Aft.
The resultant decrease of moment			23971 Ford.

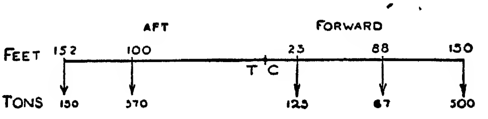


Fig 43.

$$\text{Mean rise} = \frac{\text{tons}}{\text{T.P.I.}} = \frac{1212}{53} = 22{\cdot}9 \text{ inches}$$

Total trim $= 23971 \div 1423 = 16{\cdot}8$ inches

	Forward ft.	Forward ins	Aft ft.	Aft ins.
Original draught	22	01	24	10
Mean decrease	1	10·9	1	10·9
	20	02·1	22	11·1
Half total trim	−	8·4	+	8·4
New draught	19	5·7	23	7·5

Example.—Assuming the ship's draught as in previous question to be 19 ft. 5·7 ins. forward, 23 ft. 7·5 ins. aft, required to find the distance 400 tons will need to be moved to bring the ship on to an even keel; I.T.M. 1423.

	ft.	ins.
Draught forward	19	05·7
aft	23	07·5
Total trim	4	01·8 = 49·8 inches

If total trim $=\frac{\text{total moment}}{\text{I.T.M.}}$ then $49{\cdot}8$ ins. $=\frac{\text{moment}}{1423}$

Moment $=49{\cdot}8\times1423=70865{\cdot}4$ foot-tons and—
Distance $=$ moment $\div$ weight $=70865{\cdot}4\div400=177$ ft.

The centre of gravity of the 400 tons weight would need to be shifted forward 177 feet from its present position to bring the ship on to an even keel, or 800 tons moved forward half the distance, viz., $88\frac{1}{2}$ feet, would bring about the same result.

STABILITY EQUATIONS.

1. $G G_1 = \frac{d \times w}{W}$

Where $G G_1$ is the shift of G
d the distance through which
w the weight has been moved
W the ship's displacement.

2. $G M = G G_1 \cot \theta.$

Where $G M$ is the metacentric height
θ the angle of heel.

3 $G M = \frac{d \times w}{W} \cot \theta.$

4. $G Z = G M \sin \theta.$

Where $G Z$ is the righting arm.

5. I.T.M. $= \frac{L G M \times W}{12 \times l}$

Where I.T.M. is the inch-trim-moment
$L G M$ the longitudinal metacentric height
W the ship's displacement
l her length between perpendiculars

6. I.T.M. (approx.) $= \frac{30\ T^2}{B}$

Where T = tons per inch immersion
B = breadth of ship

7. $BM = \dfrac{L^2}{12\,d}$

Where L is the length of the vessel
d is the draught
BM the longitudinal metacentric height.

8. $\text{Total trim} = \dfrac{\text{Trim moment}}{\text{I.T.M.}}$

9. $\text{T.P.I.} = \dfrac{L \times B}{12 \times 35}$ for box-shaped vessels.

10. $\text{T.P.I.} = \dfrac{L \times B \times \text{Coefficient}}{12 \times 35}$ for ship-shaped vessels.

11. $\text{Transverse BM} = \dfrac{B^2}{12d}$ for box-shaped vessels.

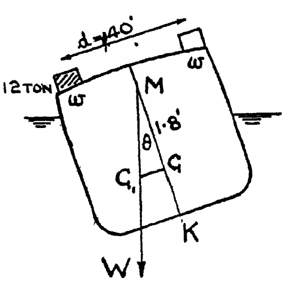
where B is the breadth and d the draught.

12. $BM = \dfrac{B^2}{6d}$ is constant for a triangular body apex down

13. $\text{Longitudinal GM} = \dfrac{L^2}{12d}$ for box-shaped vessels.

Stability equations are simplified when applied to box-shaped vessels of rectangular form as indicated by the following worked examples. A few similar examples for practice are given in the exercises which follow from number 34 onwards.

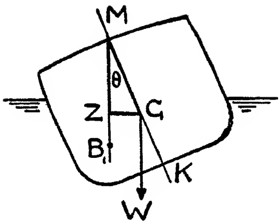
On a vessel of displacement 4000 tons and transverse metacentric height 1·8 feet, a weight of 12 tons is moved 40 feet across the deck, find the angle of heel.



$$GG_1 = \frac{d \times w}{W} = \frac{40 \times 12}{4{,}000} = \cdot 12 \text{ feet.}$$

$$\text{Cot}\,\theta = \frac{GM}{GG_1} = \frac{1\cdot 8}{\cdot 12} \quad \begin{array}{l}\log 0\cdot 255273 \\ \log 9\cdot 079181\end{array}$$

Angle of heel $\theta = 3° \; 49'$ Cot $11\cdot 176092$



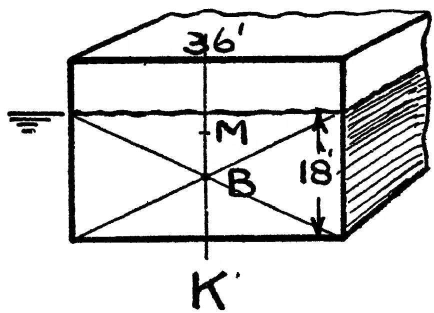
Given KM 16 feet, KG 13·8 feet, displacement 6000 tons, angle of heel 8°, find the vessel's righting moment.

$$GZ = GM \sin\theta = 2{\cdot}2 \text{ ft} \times \text{Nat} \sin 8°$$

$$GZ = 2{\cdot}2 \text{ ft.} \times {\cdot}1391 = {\cdot}306$$

$$\begin{aligned}\text{Righting moment} &= W \times GZ\\ &= 6000 \times {\cdot}306\\ &= 1836 \text{ foot-tons}\end{aligned}$$

Find the height of the transverse metacentre about the centre of buoyancy in a box-shaped vessel, 36 feet beam and 18 feet draught.



$$BM = \frac{B^2}{12d} = \frac{36 \times 36}{12 \times 18} = 6 \text{ feet.}$$

Metacentre is 6 feet above C. of B.
$KB = 9$ feet, $BM = 6$ feet ∴ $KM = 15$ feet.

A box-shaped vessel 200 feet long and 30 feet beam, what will be her tons per inch immersion ?

$$\text{T.P.I.} = \frac{L \times B}{12 \times 35} = \frac{200 \times 30}{12 \times 35} = 14{\cdot}285 \text{ tons.}$$

A rectangular-shaped vessel draws 8 feet. If her I.T.M. = 480 foot-tons, and 40 tons is shifted 36 feet towards the stern, find the new draughts.

$$\text{Total moment} = 40 \times 36 = 1440 \text{ foot-tons.}$$

$$\text{Total trim} = \frac{\text{Total moment}}{\text{I.T.M.}} = \frac{1440}{480} = 3 \text{ inches.}$$

	F	A
Original draught ...	8ft. 0ins.	8ft. 0ins.
Half-trim	$1\frac{1}{2}$ins.	$1\frac{1}{2}$ins.
New draught ...	7ft. $10\frac{1}{2}$in	8ft. $1\frac{1}{2}$in.

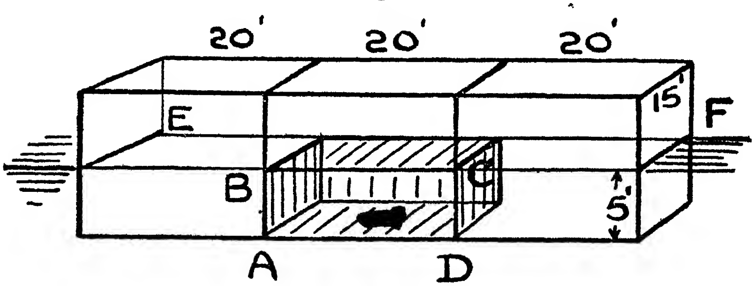
Given the following ship dimensions, find her coefficient of fineness.

L, 450ft., *B* 56ft., d 24ft., displacement, 12,900 tons.

$$\text{Displacement in tons} = \frac{\mathrm{L \times B \times d \times coeff.}}{35}$$

$$\therefore \text{coeff.} = \frac{\text{Displ.} \times 35}{L \times B \times \mathrm{d}} = \frac{12900 \times 35}{450 \times 56 \times 24} = \cdot 74$$

A rectangular tank, 60 feet long, 15 feet wide, and 10 feet deep, floats at a draught of 5 feet. The tank is divided into three equal compartments, each 20 feet long. If the middle compartment gets bilged what will be the new draught of the tank?



When a compartment gets flooded and laid open to the sea, the mean sinkage of the vessel is equal to the volume of the lost buoyancy divided by the area of the waterplane remaining intact. That is to say :—

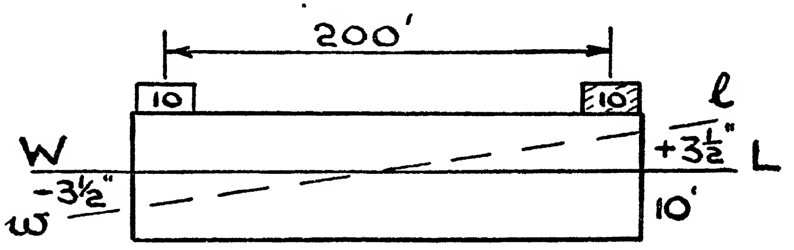
$$\text{Mean sinkage in feet} = \frac{\text{Volume of portion } ABCD \text{ in cubic feet.}}{\text{Area of } EB + \text{area of } CF \text{ in square feet.}}$$

$$= \frac{20 \times 15 \times 5}{20 \times 15 \times 2} = 2\tfrac{1}{2} \text{ feet.}$$

The new draught is 5 feet + $2\frac{1}{2}$ feet = $7\frac{1}{2}$ feet.

There is no change of trim, as the centre of gravity has not changed in a fore and aft direction.

A box-shaped vessel 200 feet × 42 feet × 20 feet floats on an even keel, drawing 10 feet. A weight of 10 tons is moved from one end to the other, required her new draughts.



WL is the original waterline. *wl* is the waterline after the 10 ton weight has been shifted from one end to the other.

Find (1) T.P.I. $= \dfrac{L \times B}{12 \times 35} = \dfrac{200 \times 42}{12 \times 35} = 20$ tons.

Find (2) I.T.M. $= \dfrac{30T^2}{B} = \dfrac{30 \times 20^2}{42} = 285{\cdot}7$ foot-tons.

Find (3) Total trim $= \dfrac{\text{Trim moment}}{\text{I.T.M.}} = \dfrac{10 \text{ tons} \times 200\text{ft.}}{285{\cdot}7} = 7$ ins.

Find (4)

Draught ...	10ft. 0ins.	10ft. 0ins.
½-trim	+ 3½	— 3½
New draughts	10ft. 3½ins.	9ft. 8½ins.

Given a vessel of 2000 tons displacement and a *KG* of 14 feet, She then loads 2800 tons, *KG* 16ft., 800 tons, *KG* 13ft., 300 tons. *KG* 2ft., 200 tons, *KG* 25ft. When loaded her *KM* is 15·7 feet. Find her *GM*.

Tons.	V.C.G.	Moments.
2800	16	44800
800	13	10400
300	2	600
200	25	5000
2000	14	28000
6100		88800

$$\text{New } KG = \frac{88800}{6100} = 14{\cdot}56 \text{ feet.}$$

$$\text{but } KM \text{ when loaded} = 15{\cdot}70 \quad ,,$$

$$\text{therefore her } GM = \underline{\underline{1{\cdot}14 \text{ feet.}}}$$

Required (1) the transverse BM, (2) the longitudinal BM of a box-shaped vessel, length 150ft., breadth 30ft, draught 15 ft.

$$(1)\ \text{BM} = \frac{\text{B}^2}{12\text{d}} = \frac{30 \times 30}{12 \times 15} = 5 \text{ feet.}$$

$$(2)\ \text{BM} = \frac{\text{L}^2}{12\text{d}} = \frac{150 \times 150}{12 \times 15} = 125 \text{ feet.}$$

QUESTIONS.

1. What is meant by the moment of a force?

2. What conditions must be fulfilled to maintain equilibrium when parallel forces are acting on a body?

3. Explain what is meant by moment=arm × weight.

4. What is the difference between levers of the first, second and third class?

5. Describe and illustrate what is meant by a couple.

6. Describe what is meant by a body being in stable, unstable and neutral equilibrium. Illustrate your answer in the case of a cone.

7. Explain what is meant by (i) displacement; (ii) coefficient of fineness of a ship.

8. Define the terms (i) centre of buoyancy; (ii) centre of gravity; (iii) transverse metacentre; (iv) moment of stability as applied to a ship.

9. Draw figures and describe exactly the conditions required to produce stable, unstable and neutral equilibrium in a ship.

10. A ship at sea rolls violently, what may this be attributed to?

11. Explain what is meant by a ship being (i) too stiff; (ii) too tender; and what might be done to remedy the conditions?

12. Explain the abbreviations KM, KG and GM.

13. Draw a figure to illustrate a ship having a negative GM.

14. When and by whom is the initial KG determined ?

15. Describe in detail the inclining experiment to ascertain the GM of a new ship.

16. Define the terms (i) trim ; (ii) tipping centre ; (iii) tons per inch immersion ; (iv) inch trim moment ; (v) total trim.

17. Explain the principle of computing the total trim of a vessel when a weight is moved forward or aft.

EXERCISES.

18 In an inclining experiment 100 tons of ballast was shifted from starboard to port, its centre of gravity moving through a distance of 30 feet and inclining the ship 8°—ship's displacement 9000 tons. Required the *G M*. *Answer.*—2·37 ft.

19. The displacement of a ship was 2600 tons when an inclining experiment was being conducted. A weight of 3 tons was moved 40 feet transversely from port to starboard and a plumb line 29 ft. 6 ins. long was deflected 2 inches. Find the *G M*. *Answer.*—8·17 ft.

20 A ship is loaded as follows:—

Cargo—Tons	500	750	620	550	400	300	200
V.C.G.—Feet	12	14	16	18	20	22	23

Initial displacement of ship 1600 tons and *K G* 12 feet If *K M* in load condition is 17 feet, find the new *G M*.

Answer.—*G M* 1 8 feet.

21. A vessel's displacement on arrival in port is 6000 tons, the V.C.G. being 16 feet. Cargo is to be discharged as follows when *K M* will be 13·5 feet. Find what the *G M* will be after discharging from—

'Tween deck	1500 tons,	V.C.G.	21 ft.
Lower holds	2000 ,,	,,	17 ,,
,,	1200 ,,	,,	12 ,,

Answer.—1·1 feet.

22. A tanker has 10,000 tons of oil in her main tanks, the C. of G being 20 feet above the keel; ten summer tanks each of 200 tons capacity having their C. of G. 30 feet above the keel. The ship's light displacement is 4500 tons and initial C. of G. 18 feet above keel. If the *K M* in load condition is 22 feet, find the new *G M*.

Answer.—*G M* 1·3 feet.

23. A ship of 5000 tons displacement has a weight of 200 tons shifted from 10 feet above her C. of G. to 10 feet below it. Find the new *G M* the old *G M* being — 3 inches.

Answer.—*G M* 6·6 inches.

24. (i) From the following information calculate the ship's *G M*. Displacement 4650 tons in light condition and V.C.G. 22 feet, the *K M* after the following loads were put on board being 23·6 feet.

Tons	1500	2500	1700	1950	1700	1000
V.C.G.—Feet	22	24	26	28	18	16

Answer.—*G M* 10·8 inches.

(ii) The following bunkers were worked off during the passage. Required the new GM, assuming the KM for the new draught to be 24 feet:—

Tons	300	200	500
V.C G.—Feet	24	26	18

Answer.—GM 1·2 feet.

25. *Example*—From the following information construct a cargo plan and fill in the column headed "Moments," also the blank spaces and compute the ship's GM when loaded.

Given light displacement 2000 tons, height of centre of gravity (KG), 12 feet height of metacentre (KM) 17 feet when loaded with cargo as indicated below.

Compartment		Contents	Weight Tons	V C G Feet	Moments
No 1.	Lower	Coal	800	11	
	'Tween deck	General	200	23	
No 2.	Lower	Rails	300	$6\frac{1}{2}$	
		Paint	100	15	
		Tubes	300	15	
		Cement	100	15	
	'Tween deck	General	300	23	
No 3.	Lower	Cement	500	7	
		Bales	100	15	
		Paper	200	15	
	'Tween deck	General	200	23	
No. 4.	Lower	Coal	700	11	
	'Tween deck	General	200	23	
Side bunkers			400	9	
Weight of ship			2000	12	
			6400		

$$KG^1 = \frac{\text{moment}}{\text{weight}} = \underline{\qquad} = \qquad \text{feet}$$

KG^1 in load condition $=$ feet

KM „ „ $=$ feet

G^1M „ „ $=$ 4·15 feet. *Ans.*

26. (i) The vertical centre of gravity of a ship of 3500 tons displacement in light condition is 18 feet above the keel. Cargo is to be received and stowed as follows:—

Weight—Tons	400	1000	1200	1100	900	600	400
V.C.G.—Feet	16	18	20	24	26	28	30

Find the position of the resultant C. of G., and also the *G M* if the metacentre is 20·5 feet above the keel.

Answer.—*G M* —·4 feet.

(ii) The above *G M* being unsatisfactory it is decided that two ballast tanks shall be run up, No. 3 tank 300 tons, V.C.G. 2 ft. and No. 4 tank 400 tons, V.C.G. 1·5 ft. Find the new *G M* assuming the *K M* to be 20·5 feet.

Answer.—*G M* 1 foot.

27. Given the following information from a cargo plan. Find the new C. of G., and if the *K M* is 22 feet find also the *G M*.:—

Weight—Tons	1000	1500	1250	1100	900	600	400
V.C.G.—Feet	24	22	21	19	23	25	18

Light condition of ship 3250 tons displacement, initial C. of G. 20 feet above keel.

Answer —·8 feet.

28. At the first port of call the following cargo was discha ged from the above ship, find the new *G M* assuming *K M* to be 22 feet:—

Weight—Tons	400	300	500	600
V.C.G.—Feet	20	22	23	24

Answer.—1·1 foot.

29. A ship arrived in port, draught 21 ft. 00 ins. forward, 23 ft. 00 ins. aft, and discharged cargo as follows:—If her T.P.I. is 45 tons and her I.T.M. is 1100 foot-tons, find her new draught.

Cargo in tons	200	450	300	500	200
Distance from T.C. in feet	30F	25 F	50 F	35 A	40 A

Answer.—17 feet 8½ ins. forward.
20 „ 2½ „ aft.

30. It is desired to bring a ship on to an even keel, her present draught is 17 ft. 08·2 ins. forward, 20 ft. 01·6 ins. aft. and I.T.M. 1100. foot-tons. What distance must 300 tons of cargo be shifted forward to do so?

Answer.—107·8 feet.

31. A ship in light condition has displacement of 2000 tons, centre of gravity being 17 feet above keel. She loads:—

(*a*)	5000	tons cargo C of G.	16 feet above keel.
(*b*)	300	,, ,,	10	,,
(*c*)	100	,, ,,	20	,,

Find the height of the centre of gravity of loaded ship.

Answer.—New $K\ G$ 16·1 feet.

32. A vessel displaces 4000 tons. Initial transverse metacentric height 1·2 feet. A weight of 40 tons deck cargo is shifted to the lower hold a distance of 20 feet vertically. Find the final metacentric height.

Answer—New $G\ M$ 1·4 feet.

33. A vessel in light condition displaces 1800 tons and the C of G. is 10 feet above the keel. She loads 3400 tons of cargo 9 feet above keel, and 400 tons bunkers 16 feet above keel. The height of the transverse metacentre in the loaded condition is 12 feet above the keel. Find the metacentric height.

Answer.—New $G\ M$ 2 ft. 2·2 ins.

34. A box-shaped vessel 600 feet long is floating at a mean draught of 10 feet forward and aft. If the moment to change trim 1 inch is 240 foot-tons, find the change of trim caused by shiftingg 20 tons aft through 48 feet.

Answer.—9 ft. 10 ins. forward, 10 ft. 2 ins. aft.

35. Ship 2000 tons displacement. A weight of 10 tons is shifted 20 ft. transversely across the deck. Find the shift of the centre of gravity. If the vessel were upright before shifting the weight and she heeled 8°, find the initial transverse metacentric height.

Answer.—$G\ G_1$=0·1 ft. $G\ M$=0·7 ft.

36. A box-shaped vessel floating upright, at 7 feet draught is 180 ft. long, 20 ft. wide, 10 ft. deep, and has no $G\ M$. Find the $G\ M$ when a weight of 40 tons is shifted from the deck to the bottom of the vessel.

Answer.—$G\ G^{1}$=0·55 ft. $G\ M$=0·55 ft.

37. Ship 1500 tons is floating at 12 ft. draught. A weight of 25 tons is moved from the lower hold port side to the 'tween deck starboard side through a distance of 55 ft. Find the shift of $G\ G$.

Answer.—$G\ G_1$.=11 ins.

38. Vessel 210 ft. long is drawing 10 ft. on even keel in salt water. A weight of 25 tons is moved horizontally towards the stern 30 ft. Find the new draughts, assuming the centre of flotation to be amidships and the I T.M.=250 foot-tons.

Answer.—Forward 9 ft. 10½ ins. Aft 10 ft. 1½ ins.

39.—Ship 300 ft. long, draught 21 ft. forward and 22 ft. aft. The I.T.M.=480 foot-tons and a weight of 40 tons is moved 50 ft. aft. Find the new draughts.

Answer.—Forward 20 ft. 9·9 ins. Aft 22 ft. 2·1 ins.

40. Find the total pressure on a keel plate 20 ft.×3 ft. at 10 ft. draught on an even keel in salt water.

Answer.—38,400 lbs.

41. A vessel's light displacement is 1800 tons K.G.=10 ft. She loads 3400 tons of cargo, K.G.=9 ft., and 400 tons bunkers, K.G. 16 ft. Find the new K.G.

Answer.—9·82 ft.

42. Ship of 1600 tons displacement has C.B. 8 ft. above keel, K.G. 10 ft and K.M. 11·5 ft. Find the angle of heel if a weight of 8 tons were moved 20 ft. transversely

Answer.—3° 49′.

43. A box-shaped vessel 200 ft.×40 ft.×18 ft. floats at a draught of 10 ft. Find K.M.

Answer.—K.M. 18·33 ft.

44. A vessel of 5000 tons displacement with K.G. 15·8 ft. has her transverse metacentre 18 ft. above the keel. Find her righting moment when she is heeled 7°.

Answer.—Righting moment of 1340 foot-tons.

45. A ship of 3330 tons displacement draws 17 ft. 0 ins. forward and 16 ft. 6 ins. aft. Her T.P.I. is 21 and her I.T.M. 275 foot-tons. Her No. 5 tank of capacity 78 tons is run up. Find her new draught if CG of the ballast is 50 ft. abaft the tipping centre, which is assumed to be amidships.

Answer.—Forward 16 ft. 8·6 ins. Aft 17 ft. 4·8 ins.

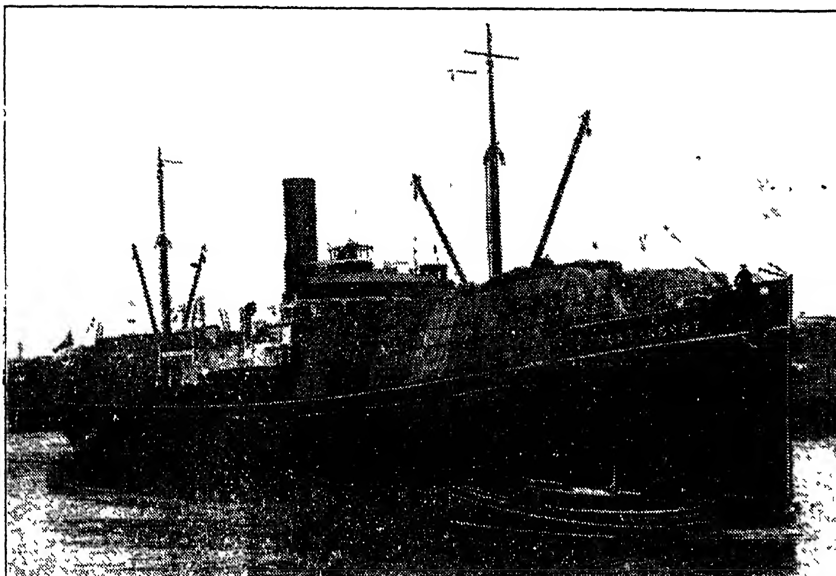
46. Required (1) the transverse B.M.; (2) the longitudinal B.M.;

(3) tons per inch immersion (4) inch trim moment of a rectangular shaped vessel length 200 ft., breadth 30 ft., draught 10 ft.

Answer.(—1) $7\frac{1}{2}$ feet; (2) 666.6 ft.; (3) $14\frac{2}{7}$ tons; (4) 204 foot-tons.

47. A rectangular tank 100 feet long, 10 feet broad, 12 feet deep draws 4 feet of water. The tank is divided into five equal watertight compartments, but Nos. 2 and 4 get bilged; find the mean sinkage due to the loss of buoyancy.

Answer.—$2\frac{2}{3}$ feet.



A Cargo of Esparto Grass.

CHAPTER XIX.

THE REGISTRATION AND CERTIFICATION OF SHIPS AND SEAMEN.

The Shipping Industry is subject to the provisions of the Merchant Shipping Act, which is the longest Act on the Statute Book. The responsibility for its administration is vested in several Government Departments.

The Board of Trade is charged with the duty of not only drawing up rules and regulations for the safeguarding of life and property at sea but of ensuring that they are adhered to; such, for example, as the Load Line Regulations which are now International in application, the carriage of goods by sea, life-saving appliances on board ship, navigational apparatus, registration of ships, inquiry into casualties, shipping and discharging crews and their accommodation on board, certification of masters, mates, engineers and lifeboatmen.

The Customs and Excise is the office through which ships are registered as having cleared inwards and outwards at British ports. All goods imported into the country or exported must be recorded and vouched for at the Custom House and duty thereon paid, or guaranteed, before they are released for shipment.

The Ministry of Health is responsible for granting pratique to vessels arriving from overseas, and the visiting medical officer decides whether the ship is healthy, suspect or infected. The inspection of the crew accommodation from a sanitary point of view is carried out by this Department and also the deratisation of ships.

The Home Office is concerned with the administration of the Factory Act as applied to docks and ships.

The Ministry of Labour, through its exchanges, deals with questions of employment, unemployment, payment of benefits, etc.

Ministry of Agriculture and Fisheries attends to the carriage of live stock in home trade and foreign-going vessels, also to the interests of the fishing industry generally and the policing of prohibited fishing areas.

Port and Local Authorities are responsible for the administration of the areas within their jurisdiction and of such statutory powers as have been granted to them by the Legislature, such as the effective lighting and buoying of harbour approaches, pilotage, levying dock dues, etc.

Classification Societies are not Government Departments although they work in co-operation with the Marine Department on matters affecting the seaworthiness of ships.

There seems to be a somewhat unnecessary distribution of ship inspectorate duties amongst the several Government Departments, particularly that of the Board of Trade and the Home Office, and when, as on the recent occasion of a modern up-to-date cargo vessel undergoing a routine overhaul, there were seventeen individual surveyors inspecting various things during the ten days she was in port it would seem that there is an opportunity here for introducing a little more concentration of supervisory control.

His Majesty's Stationery Office.—Passing reference to such regulations as enter directly into the business of the seaman have been made throughout this book, but only briefly, and in part, as the precise detail of the many regulations and their modified application to meet uncommon conditions occupies many pages of numerous publications. The Board of Trade issues periodically a "List of the Principal Acts of Parliament, Regulations, Orders, Instructions, Notices, etc., relating to Merchant Shipping," with a special list of any Supplementary Circulars that may have been issued since the previous List was published. The List may be obtained from His Majesty's Stationery Office, Adastral House, Kingsway, London, W.C.2, price 6d.

The existence of these publications is not known generally to seagoing men as they are grouped according to the following interests :—Shipowners ; Fishing Boat Owners ; Boiler Makers and Users ; Boat Builders ; Shippers of Cargo ; Manufacturers of Anchors and Chain Cables, Fire Extinguishers, Fog Horns and

Steam Whistles, Nautical Instruments and Ships' Navigation Lanterns.

We give here a list of the more important of these publications but not of the numerous supplements issued separately as circumstances may dictate.

1. Anchors and Chain Cables Act. 1/-
2. Coal Cargoes, various circulars.
3. Dangerous Goods. 2/-
4. Deck Cargoes. Report on Timber. 2/-
5. Emigrant Ships. 1/-
6. Fire Precautions, various circulars.
7. Grain Cargoes. 6d.
8. Instructions as to Survey of Life-saving Appliances. 2/6
9. Load Line Rules. 1/9
10. International Convention respecting Load Lines. 3/-
11. National Health and Pensions Insurance.
12. Instructions as to the Survey of Passenger Steamships. 1/6
13. Safety of Life at Sea, International Convention. 4/-
14. Tonnage Measurements. 9d.
15. Instructions as to the Survey of Master's and Crew Spaces. 6d.
16. Examination Regulations; Masters and Mates in the Mercantile Marine. 1/6

"Carriage of Dangerous Goods and Explosives in Ships," 1935. H.M.S.O. 2/-.—This is a Report of a Departmental Committee appointed to consider the existing Board of Trade Memorandum on the Carriage of Dangerous Goods. The Board has decided to adopt in substitution of the present Memorandum that part of the Report which contains particulars of packing, labelling and stowing applicable to various substances.

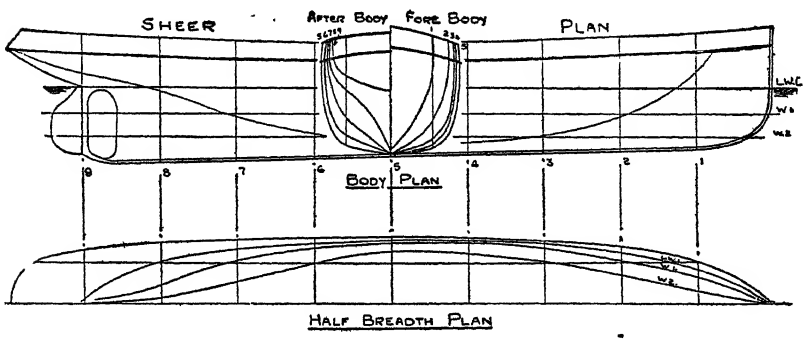
The substances have been classified into seven categories, viz. 1. Explosives. 2. Compressed "permanent," liquefied and dissolved gases. 3. Substances which become dangerous by interaction with water or air. 4. Substances giving off inflammable vapours. 6. Poisonous substances. 7. Miscellaneous.

A section is devoted to each category in which is grouped in alphabetical order the names of dangerous goods with instructions to manufacturers, packers and stevedores regarding the packing,

marking and stowage thereof, with notes for the information of officers as to the dangerous properties of the various substances.

The danger may arise from liquefied gases that are poisonous or inflammable, such as chlorine, hydrocyanic acid, etc.; or gases carried in cylinders under pressure which may expand with heat and burst the containers. Leakage of vapour which may form explosive or inflammable mixtures with air, or substances that become dangerous on contact with water, calcium preparations for example, petroleum spirits, etc.

In general, all such goods should be stowed away from foodstuffs and living quarters, in cool, well ventilated spaces, and if on deck they should be protected from the rays of the sun. The quantity of deck goods should not exceed 50 per cent. of the total deck area. Cylinders containing gases under pressure should be stowed not less than 8 feet from the ship's side under cover. Dangerous goods to be distinctively labelled and the nature of the danger, whether inflammable, corrosive or poisonous to be clearly stated on the package.



PLANS.

The upper drawing is a profile or sheer plan of a vessel showing the position of three waterplanes.

The waterplanes are projected on to the half breadth plan, which exhibits as curves the shape of each waterplane area as if the vessel were sliced into horizontal sections at the level of each respective waterplane.

The vertical lines numbered 1, 2, 3, etc., are frame stations,

and these are drawn on the body plan, as they would be seen if the ship were viewed end on from forward and from aft. The frames are bent to their curvature as shown on the body plan.

The fore and aft line on the half breadth is called a bow and buttock line, and it is represented on the body plan by the two vertical lines on the fore and after body's. If the ship were sliced vertically for the whole of her length along that line her side would be laid open and the shape of the opening would be the same as the curved line running fore and aft on the sheer plan.

By reconciling or "fairing up" the respective lines and curves on the three plans the naval architect designs the shape the vessel will eventually be when built.

THE NEW SHIP.

The preliminary arrangements to finance the ship having been satisfactorily completed a ship is ordered. The contract price usually stipulates that the builder shall receive one-fifth when the keel is laid, one-fifth when framed, one-fifth when plated, one-fifth when launched and the final fifth of the purchase price when the completed ship is handed over to the owners.

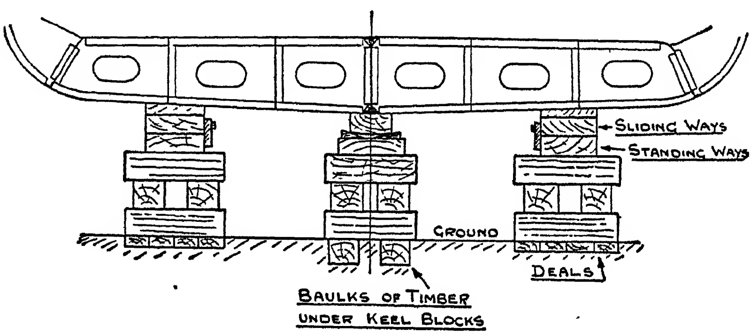


Fig. 1.—The Keel Blocks are removed before the vessel is Launched.

Plans of the proposed vessel are submitted by the builder to the Classification Society under whose rules she is to be built, either Lloyd's or British Corporation. During the period of her construction the ship is frequently inspected by the surveyors of the Society. Reference is made on pages 482 and 483 as to how the scantlings of various parts of the structure is regulated by numerals. The

Equipment Numeral, which is perhaps of more interest to the deck executive than the others, is determined by the Second Numeral, $L \times (B + D)$, with some modification for superstructures; for example, a ship of the dimensions of the *Caledonian Monarch*, a vessel of 9,400 deadweight, has an Equipment Numeral 37195, and we find, on referring to Lloyd's Tables, that such a vessel must have **three bower anchors** weighing 63¾ cwts. each, tested to 50½ tons.

Stud chain cable, 270 fathoms, minimum size 2¼ inches, proved to a load of 91 tons, breaking test 127½ tons, minimum weight 682 cwts.

One stream anchor, weighing 17½ cwt., tested to 18½ tons and 90 fathoms of 1¼-inch stream chain, or, as an equivalent to chain, 90 fathoms of 4¾-inch steel wire of breaking test, 47 tons.

A towline, 120 fathoms of 14-inch hemp, or, as an equivalent, 120 fathoms of 5-inch wire.

Two hawsers, 90 fathoms each of 8 inch hemp, or 2¾-inch wire.

Two warps of 7-inch hemp, or 2½-inch wire.

A vessel of approximately 5,000 tons deadweight having an equipment number 24200 is provided with bower anchors weighing 45 cwt. each and a 12-cwt. stream anchor with a 4¼-inch steel wire.

The size and number of shrouds is regulated by the length of the mast measured from the upper deck to the hounds. A mast, 50 feet long, must be fitted on each side with three shrouds of at least 3¾-inch wire, one topmast backstay of 3-inch wire and one forestay of 3½-inch wire.

LAUNCHING THE SHIP.

The weight of the vessel during construction is borne on the keel blocks and on bilge shores, but when being launched she slides down on launching ways. These are rectangular timbers laid the whole length of the ship, parallel to each other, to form a trackway extending beyond the slipway into the water. They measure about 4 feet wide and 18 inches thick, placed on each side of the keel about one-third of the vessel's breadth apart with a declivity of about eleven-sixteenth inch to the foot.

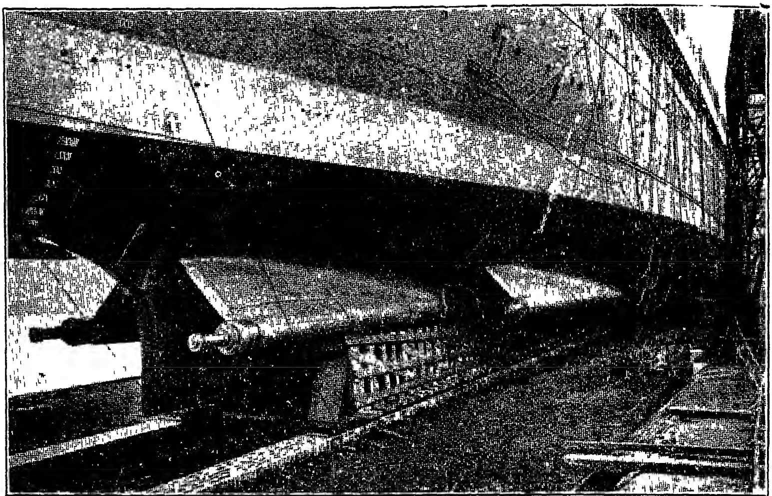


Fig 2.—View of Launching Ways and After Poppet.

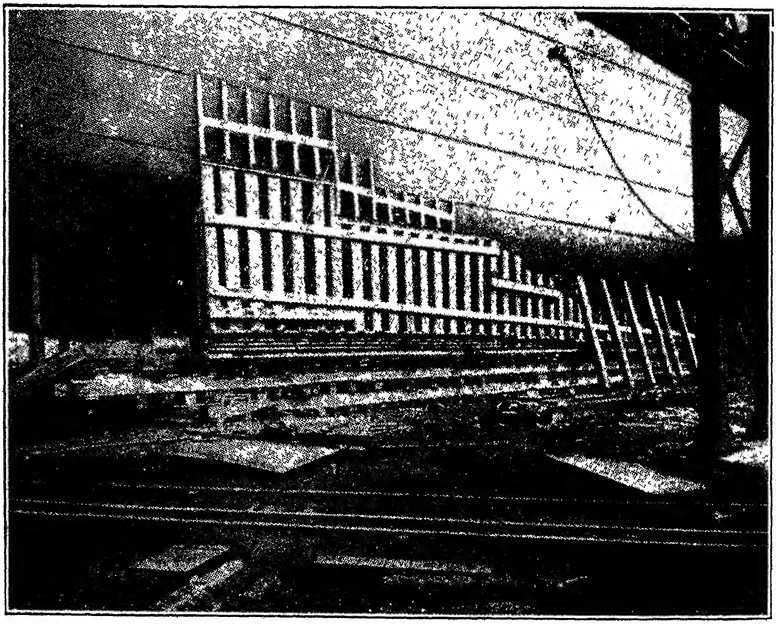


Fig. 3 —Forward Poppet.

The ways are in two parts; the standing ways have their foundation on the ground and have vertical lengths of wood bolted along their outer edge to prevent the sliding ways, which rest on top of the standing ones, from slipping outwards.

A framework of wood and iron is built under the vessel and wedged up tight under her bottom to form a cradle for her to rest on. The sliding part of the ways, that is the top logs, forms the bed of the cradle which supports the weight of the ship for about 80 per cent. of her length. The ends of the cradle are carried higher up the ship's side than the intermediate part, the end part of the structure being called the forward and after poppets. When ready for launching the building blocks are knocked clear of the ship, the cradle takes the weight of the vessel, then, when the last supporting block is removed, the moving log, cradle and ship all slide together down the well greased ways. The vessel is then taken to the fitting out berth.

REGISTRATION AND CERTIFICATION OF SHIPS.

Carving Note.—Before the ship is handed over by the builders the owner gets from the Custom House a form called a "carving note" which he fills in, stating the proposed name of the vessel, her port of registry, tonnage, etc., and requests that she may be registered. This note takes its name from the fact that the ship's tonnage and official number are carved or cut out on her main beam or hatch coaming.

The Certificate of Registry is then granted by the Custom House. It is, as it were, her birth certificate. It gives particulars of the ship, when and where built, her type, name, port of registry, official number, signal letters, horse power of engines, principal dimensions, cubic capacity and other points of identification, also the owner's name.

The master's name is endorsed on the register. This must be done as soon as he takes command by the Chief Officer of Customs at the Custom House, or by the British Consul at a foreign port. Changes of ownership must be endorsed on the certificate, and if the ship be lost, or passes under a foreign flag, the certificate is to be returned to the Board of Trade.

The certificate of registry is inspected by Custom House officers at home and abroad every time the ship is entered inwards or outwards at a port. The Shipping Office routine with regard to depositing the Register, the crew's articles of agreement and recording changes in the crew as carried out at a home port in the Mercantile Marine Office is transacted abroad by the British Consul.

Anchors and Chain Cables Act.—A certificate is granted by a Lloyd's Proving House licensed by the Board of Trade for the testing of anchors and chain cables according to this Act. Refer back to pages 122 and 123.

The Freeboard and Load Line Certificate is granted by the Board of Trade, or by one of the three assigning authorities, and subsequently ratified by the Board of Trade. Refer also to pages 376 to 378.

Life-Saving Appliances Safety Certificate.—The Marine Department of the Board of Trade is charged with the responsibility of ensuring that the Rules and Regulations relating to the Safety of Life and Property at Sea are complied with. The surveyors are departmentalised as Engineer, Shipwright and Nautical Surveyors; the engineers attend to the engines and boilers; the wrights to the hull and structure; the nauticals to the navigational and life-saving appliances. The duties of each may occasionally overlap.

Cargo Vessels are granted a L.S.A. Certificate by the Board of Trade after inspection of life-saving appliances, lights, sound signals, etc. The Surveyors are at liberty to board British ships at any port in the U.K. to make this inspection or they may be called in for the purpose. The period of validity of this certificate is not specified, but they are renewed from time to time.

Passenger Vessels.—When a passenger vessel is to be surveyed, the hull is examined in dry dock and cables ranged, shackle pins removed and replaced, and her certificate of cables and anchors verified. All holds and bilges are thoroughly cleaned and examined. Boats, davits and equipment, life-saving appliances, lights, signals, compasses, lifebelts and lifebuoys, fire-extinguishing apparatus, etc., all inspected and passed; boats lowered into the water and

examined for leakage ; medical stores, hospitals, dispensary are also inspected by the Board of Trade.

Crew's accommodation examined for space, fittings, ventilation, ladder ways, lavatory conveniences, and the certificates of the master, officers and engineers inspected. All watertight doors, deck equipment and gear are subject to inspection, and in fact everything that the Surveyor may consider tends to make any part of the ship and conveniences efficient. Compasses must be adjusted occasionally, and a certificate is required of the master that any errors are known to him.

Safety Radiotelegraphy Certificate.—Under the Merchant Shipping Safety and Load Line Convention, 1932, the wireless apparatus of both passenger and cargo vessels is subject to an annual survey by the Board of Trade. In the case of cargo vessels a Safety Radiotelegraphy Certificate is issued, but in passenger ships this certificate is embraced by the Passenger and Safety Certificate.

International Load Line Certificate.—Under the above Convention, the freeboard is required to be verified annually. This is carried out by the Classification Surveyor, and the International Load Line Certificate is endorsed accordingly in the space provided. The certificate is renewed every four years when the class survey is carried out.

Survey of Master's and Crew Spaces.—A deduction is allowed from the tonnage measurement of the vessel in respect of space solely appropriated for the use of seamen and apprentices, the deductible space consisting of sleeping rooms, messrooms, bathrooms, washing places, oilskin and overall lockers, pantries, food lockers, drying room, hospital.

There must be for each man a space not less than 120 cubic feet and 15 superficial feet, the space to be at least 6 feet high, and the flooring to be of wood or an approved composition laid on a steel deck.

The living quarters must be efficiently lighted, the minimum standard to be the provision of sufficient natural light when the ship is new and paint clean, that it will be possible in clear weather to read the print of an ordinary newspaper in any part of the space.

If this standard is impracticable electric lighting may be accepted under approved conditions. Satisfactory ventilation must be provided and the spaces protected from effluvium which may be caused by cargo or bilge water. Provision should be made to ensure daily a sufficient supply of fresh water for washing purposes.

Crew Spaces must be Clean and Clear.—In addition to a daily cleaning out, crew spaces should be thoroughly cleaned, the partitions, sides and bunks being washed three or four times a year, and the space should be painted, preferably white or a light colour as a rule, every two years. All crew spaces must be kept in a fit condition for the proper accommodation of the men who occupy them, and if in a dirty condition, and this condition is not remedied forthwith, the space may be disallowed as tonnage. Whenever a ship is being registered or re-registered a certificate to the effect that the crew space has been inspected must be sent by the Surveyor to the Registrar of Shipping at the port of registry.

Certificated Lifeboatmen.—Passenger ships are those carrying more than 12 passengers on international voyages or home trade. Emigrant ships are those carrying from the British Isles to any port out of Europe or the Mediterranean more than 50 steerage passengers, or a greater number than one passenger for every 20 tons of the registered tonnage.

The crews of such ships shall include for each boat at least two certificated lifeboatmen when the prescribed complement of the boat is less than 41 persons; three lifeboatmen when the boat's complement is from 41 to 61 persons; four lifeboatmen from 62 to 85 persons, and when the complement is over 85 persons five lifeboatmen per boat.

An applicant for a lifeboatmen's certificate must be at least 18 years of age, has had sufficient service at sea, and has been trained in all the operations connected with launching lifeboats and the use of oars, and that he is acquainted with the practical handling of the boats themselves. The applicant has to submit himself for examination at such times and places as may be directed by the Board of Trade, and, if found satisfactory, the Board issues a certificate. The Board of Trade hold the examination on board a ship, but only at the request of the owner, provided there be a sufficient number of candidates to form a boat's crew. No official

provision on a national basis for the effective training of ship's crews in boat work has, so far (1936), been established in the United Kingdom.

PANAMA AND SUEZ CANAL CERTIFICATES.

Under Deck Tonnage is a measure of the internal space between the top of the ceiling or double bottom in the hold and

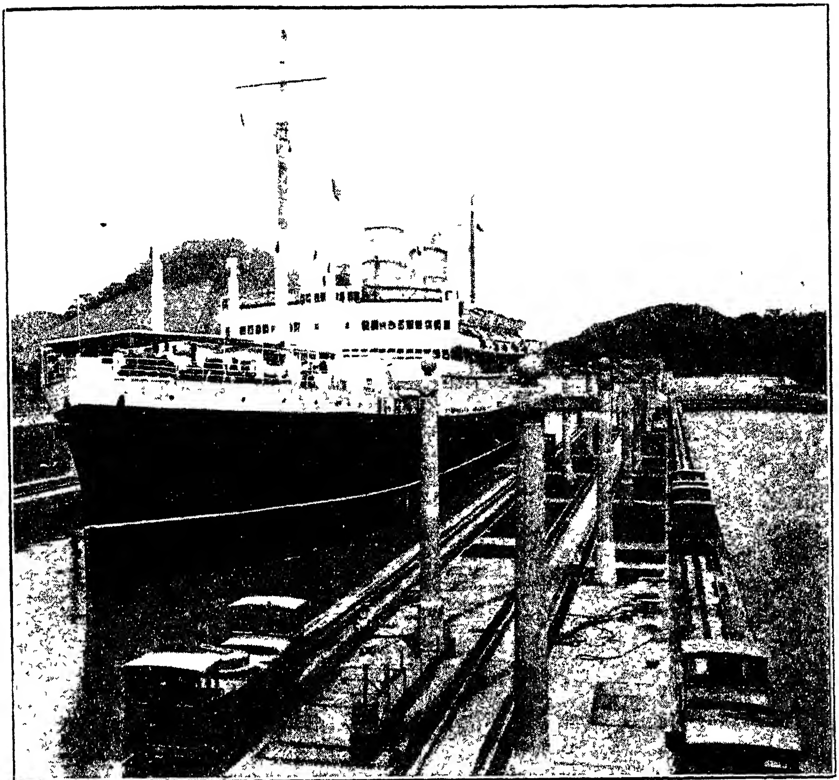


Fig. 4.—Steamship in Canal Lock.

the under surface of the tonnage deck. The unit of measurement is a ton of 100 cubic feet.

Gross Register Tonnage is a measure of the total internal volume of the ship, and is equal to the under deck tonnage plus the tonnage of all enclosed spaces above the tonnage deck.

Net Register Tonnage is the residual tonnage after various allowances for propelling power, crew spaces and navigation spaces have been deducted from the gross tonnage.

Canal dues are payable on the tonnage stated in the certificates granted by the Panama and Suez Canal Authorities respectively. The assessable tonnage space is based on the Panama and Suez rules which, in some respects, differ from each other and from the British rules, so that all vessels using these Canals must be inspected and measured for these certificates. The Panama Canal net tonnage is based on the ship's actual earning or cargo carrying capacity, and includes all covered in spaces such as forecastle, poop, bridge space, shelter deck or 'tween decks, and this tonnage determines the canal dues to be paid by the ship. The tolls are $1.25 per ton for loaded vessels and $0 75 per ton when in ballast with, in the latter case, a restriction as to the quantity of bunkers that may be allowed in lieu of ballast. The Suez Canal toll is 5/9 per ton for loaded ships and half that amount for vessels in ballast, with a levy for passengers: 5/9 for each adult and 2/10½ for each child between 3 and 12 years of age. Additional charges are made by both Canal Authorities for pilotage, towage, etc.

MINISTRY OF HEALTH.

Port Local Authority.—When a vessel enters a port from overseas she is visited by the boarding Medical Officer of Health, to whom the master gives in the following form a "Declaration of Health." If the ship is healthy the medical officer certifies that he has examined the ship and finds no medical reasons for withholding pratique.

The Immigration Officer ascertains, with regard to aliens entering the country, the length of their stay, the purpose of their visit and the amount of money in their possession. No alien is allowed to land who is a lunatic or mentally defective, or suffering from T.B., leprosy, etc., or in a verminous condition.

DECLARATION OF HEALTH

(To be rendered by the Master of a foreign-going ship arriving in Great Britain or Northern Ireland from a foreign port)

THE ATTENTION OF THE MASTER IS DIRECTED TO THE INSTRUCTIONS UNDER ARTICLES 5, 6 AND 19.

Name of Vessel ....

From .... *Via* ....

Nationality .... *Net Registered Tonnage*........................

HEALTH QUESTIONS

1. Has there been on board during the voyage * any case or suspected case of Plague, Cholera, Yellow fever, Typhus fever, or Smallpox? (Give particulars in the Schedule) . ...

2. Has plague occurred or been suspected amongst the rats or mice on board during the voyage? * ... ...

3. Are you aware of sickness or deaths amongst the rats or mice on board other than is attributable to poison or any other method employed for killing them ... ...

4. Has any person died on board during the voyage * otherwise than as the result of accident? (Give particulars in the Schedule) ... ...

5. Is there on board or has there been during the voyage * any case of illness which you suspect to be of an infectious nature? (Give particulars in the Schedule) ... ...

   NOTE.—In the absence of a surgeon, the Master *should regard the following symptoms as grounds for suspecting the existence of infectious disease*:—Fever accompanied by prostration or persisting for several days, or attended with glandular swellings; or any acute skin rash or eruption, with or without fever; severe diarrhœa or diarrhœa with symptons of collapse; jaundice accompanied with fever.

6. Are you aware of any *other* condition on board which may lead to infection or to the spread of infectious disease? ....

I hereby declare that the particulars and answers to the questions given in this Declaration of Health (including the Schedule) are true and correct to the best of my knowledge and belief.

Date .... *(Signed)* ....
(Master)

(Countersigned) ....
(Ship's Surgeon)

*If more than six weeks have elapsed since the date on which the voyage began, it will suffice to give particulars for the last six weeks.

DUTIES OF MASTER.

HEALTH CONDITIONS ON BOARD.

ARTICLE 5.—The Master of a foreign-going ship approaching a district from a foreign port must ascertain the state of health of all persons on board, and in terms of Article 13 shall fill in and sign the Declaration of Health.

ARTICLE 6 (WIRELESS MESSAGES).—If the answer to any of the questions 1 to 6 is "Yes," free pratique will not be granted by His Majesty's Customs

until the vessel has been visited by the Port Medical Officer. The Master should therefore :—

(1) Send a wireless message to the Port Local Authority stating the name of his vessel and the time when the ship is expected to arrive. This message must be sent off not more than twelve hours and not less than four hours before the arrival of the ship.

(2) If the ship is not fitted with wireless, notify the Port Sanitary Authority of the arrival of the ship as soon as possible.

ARTICLE 9 AND THIRD SCHEDULE (USE OF FLAGS AND SIGNALS).—The Master should hoist whichever of the Quarantine Signals is appropriate, as set out in page 356 of the British Edition of the 1931 International Code of Signals for Visual Signalling, in accordance with Part II. of the Third Schedule, as follows :—

"(*a*) *By Day*, during the whole time between sunrise and sunset, when the ship is within three miles of the coast or is within the limits of the district—

(i.) the Flag Signal Q, meaning—'My ship is healthy, and I request free pratique';

(ii.) the Two-Flag Signal QQ, meaning—'My ship is suspect, that is to say, I have had a case or cases of infectious disease more than five days ago, or there is an unusual mortality among rats on board'; or

(iii.) the Two-Flag Signal QL, meaning—'My ship is infected, that is to say, I have had a case or cases of infectious disease less than five days ago.'

The day signal shall be shown at the masthead, or where it can best be seen.

"(*b*) *By Night*, during the whole of time between sunset and sunrise, but only when the ship is within the limits of the district, a signal comprising a red light over a white light, the lights being not more than six feet apart and meaning 'I have not free pratique.'

The night signal shall be shown at the peak or other conspicuous place where it can best be seen."

ARTICLE 19 (DERATISATION AND DERATISATION EXEMPTION CERTIFICATES. Under Article 19, when a ship arrives from a foreign port, the ship's Deratisation Certificate or Deratisation Exemption Certificate *must* be produced for inspection by the Officer of the Port Local Authority.

This Declaration of Health must be completed and ready to deliver to the Officer of H.M. Customs, or Officer of Port Sanitary Authority, whichever shall first board the vessel.

THE MAXIMUM PENALTY FOR BREACH OF THE PORT SANITARY REGULATIONS IS ONE HUNDRED POUNDS.

FOR USE OF PORT LOCAL AUTHORITY.

Certificate.	Port of Issue.	Date.	Fumigant Used
Deratisation Deratisation Exemption			

DERATISATION.

Deratisation Certificate.— The International Sanitary Convention of 1926 made it necessary for all ships to obtain from the Port Sanitary Authority a "Certificate of Deratisation," but if a ship can be shown to the satisfaction of the Port Authority to be reasonably free from rats a "Certificate of Exemption from Deratisation" will be granted. Both certificates hold good for six months.

The onus of keeping the ship free from rats is thrown upon the ship. If the ship is kept free the Certificate of Exemption will be issued, if not, then fumigation will have to be undertaken. The certificate, when issued, must be kept on board the vessel with the ship's papers in order that it may be produced at every port. Unless this is done the ship will have to be inspected again with the possibility of fumigation having to be carried out. The certificate will be accepted by every country signing the Convention as evidence of the ship being free of rats.

Rats begin to breed from the age of two to three months, period of gestation three weeks, litter eight to ten rats, very prolific. It is estimated that the progeny of a pair of rats may reach the colossal total of 860 in the course of a twelvemonth. There are two species, the brown rat and the black rat. The brown species is a shore dweller and burrows; the black rat is a climber, frequents ships and is a plague carrier, the disease being transmitted to human beings by fleas.

RATS AND MICE (DESTRUCTION) ACT, 1919.

The attention of **Ship's Master** is drawn to the following provisions of the Act and requirements of the Local Authority :—

PROVISIONS OF THE ACT.

(1) The Rats and Mice (Destruction) Act applies to a vessel as if the vessel **were land,** and the Master of the vessel the **occupier** thereof. Section 6 (1).

(2) The Local Authority may by **notice served on the Master** of a vessel

within its district require him to take such necessary and reasonably practicable steps as are prescribed by the notice, for **preventing the escape of rats and mice from the ship,** and if the Master fails to comply with the requirements of any such notice he shall be liable, on summary conviction, to a fine not exceeding **Twenty Pounds.**

REQUIREMENTS OF LOCAL AUTHORITY.

(A) To prevent the passage of rats from the vessel to the wharf, the following precautions must be taken :—

(1) Rat guards should be affixed to mooring ropes in such manner that the passage of rats from the ship to the wharf is prevented ; or

(2) The moorings should be wrapped in canvas and tarred for about two feet as they leave the ship and reach the wharf.

(3) Cargo gangways should be withdrawn, or tarred or whitewashed, whilst the ship is " silent." Passenger gangways should be well lighted at night, or removed.

(4) Ship stores and gear should periodically be moved to prevent harbouring rats, and no refuse food-stuffs allowed to accumulate whilst in port.

(B) To rid a vessel of rats :—

(1) Ships trading with Mediterranean ports east of Marseilles or with other ports east of the Suez Canal should be deratised at the termination of each voyage, and whilst the holds are empty. Similar precautions should be observed on ships trading with South American ports, and with such other ports as are from time to time reported as infected with plague.

(2) The most effective method for destroying rats on board ship is by fumigating the holds, alleyways, cabins, food stores, pantries, living quarters, chain-lockers, and peaks with sulphur gas, and the Master or Owner of any vessel which is found to be definitely infested will be required to use this method.

(3) Simultaneously with this a deck search should be instituted of boats, steam-pipe casings, winch barrels, or other places which may afford shelter to rats.

(4) Systematic trapping should be carried out both whilst the vessel is in port and at sea. If the ship is empty, regular inspection should be made of holds, store rooms, and elsewhere, and rat hunts instituted.

(5) The keeping of cats on board is of definite advantage.

(6) It is of considerable value when rats are confined within the limits of a ship to catch them alive, to kill all the females, and to set the males at liberty on board.

(C) Precautions in handling rats :—

(1) Rats caught alive should be drowned and then burned in the ship's furnace. At no time should rats be handled directly owing to the risk

of accidental plague infection. No rats, dead or alive, must be taken outside the dock gates except by consent of the Port Local Authority.

(2) Effort should be directed to keeping the ship rat-free. Any increase in the number of rats on board or unusual mortality among them should be reported to the Port Medical Officer immediately the ship arrives in port.

N.B.—Nothing in this Act affects the power of the Port Local Authority to deal with rats as a preventive measure against plague. Under the **Plague Regulations,** any obstruction offered to an Officer of the Authority involves a penalty not exceeding **One Hundred Pounds,** with an additional **Fifty Pounds** for each day the obstruction continues.

Fumigation.—In all cases fumigation should, where possible, be carried out between the completion of discharge and commencement of loading, in order to prevent any possible damage to cargo, such as galvanised iron, tin plates, etc., by sulphur, and to moist cargo, such as salt, by hydrocyanic acid.

Preparation.—The vessel may be fumigated by sulphur fumes or hydrocyanic acid gas ; the latter is rather dangerous, and special precautions have to be taken after fumigation to ensure that the vessel is gas-free before persons, other than the sanitary officials, are allowed on board.

Limber boards should be removed in the holds and pipe casings and bilges opened up. 'Tween deck hatches removed, weather deck hatches to have alternate boards removed and covered with two thicknesses of tarpaulin. Doors to be opened if leading to the space being fumigated. Dunnage removed or stacked on an elevated platform to avoid harbourage for rats. Windsails to be suspended in readiness for ventilation when fumigation is completed.

Doors of all accommodation should be kept open to allow free flow of gas ; ports to be workable. Keys to be at the disposal of the fumigating staff before the ship is placed under gas. Cupboards, lockers, drawers, bins, fuse boxes, etc., to be open, and all beds lifted. Vents to be closed at deck outlet. Galley fires to be extinguished.

Immediately before fumigation an officer of the ship is required to sign a form certifying that all ship's crew and contractors' men are off the ship. After fumigation has commenced, no persons are allowed on the ship except the fumigation staff or officials of the

Port Sanitary Authority unless at the discretion of the medical officer or chemist in charge of the fumigation

The time required to clear the ship of gas varies from two to four hours depending upon the weather conditions, the clearance being expedited if there is a good breeze to create an active circulation of air throughout the ship. When a clearance certificate has been procured from the chemist of the fumigation contractor it will be safe for persons to go on board. Caution should be observed in opening any compartments adjacent to those fumigated that have remained locked for any reason, and a good airing should be given before such compartments are considered habitable

"**The Principle of Hygiene**" on board ship is the same as on land, and is just the observance and practice of health laws in the prevention of disease. These laws may be summed up in the one word "Cleanliness." Cleanliness in person, clothing, accommodation and surroundings; good ventilation in sleeping quarters, good sanitary and drainage arrangements, good food and temperate living.

A carbolic disinfectant should be used when washing out crews' quarters and cleaning up bilges, privies, etc. Bedding and clothing should be brought on deck for airing and ventilation when opportunity offers. Care should be taken with regard to underclothing when passing quickly from one climate to another, especially in damp and warm weather, so as to protect the body from sudden changes of temperature. It is asking for trouble to lie out on deck on a close sultry evening wearing thin cotton underwear and little else on, then to fall asleep and wake up chilled during the early hours of a dewy morning. Woollen underclothing is best. Eating tainted food or too much fruit in tropical countries is a frequent cause of gastric troubles and feverish disorders.

If infectious disease breaks out on board, such as measles, diphtheria, fevers, etc., the patient should be isolated from the rest of the crew and the ventilating, disinfecting and cleansing of all living accommodation more stringently exercised, and fumigated if need be to prevent the outbreak spreading.

The patient's clothing and bedding should be disinfected in boiling water with a little carbolic acid in it, and, after a few hours' soaking, they should be exposed to the sun to dry.

National Health Insurance applies to all persons over 16 years of age whose remuneration does not exceed £250 per annum When estimating the income of an officer there is added to his wages the value of the board and lodgings provided at the rate of 4/- per day when serving in cargo vessels and 5/- per day when in passenger vessels.

Insurable persons join an approved society; the Seamen's National Insurance Society is constituted to meet the special requirements of seafarers. The weekly contribution for members serving in foreign-going ships is 8d. for men and 7d. for women, and every four contributions paid on behalf of a contributor in any calendar year counts as five contributions.

The benefits include medical, sanatorium, dental, sickness and disablement treatment. Participation in some of the benefits depends on the number of contributions, and a proportionate loss of benefit is incurred if the member gets into arrears with his contributions

THE ANIMALS (SEA TRANSPORT) ORDER OF 1930. (Pamphlet No. 923).

The Ministry of Agriculture and Fisheries is empowered under the Disease of Animals Act to issue Regulations relating to vessels and animals carried thereon; animals being defined as cattle, sheep, goats, all other ruminating animals, and swine.

Restrictions.—Animals shall not be carried on more than three decks, nor on an open main (freeboard) deck, nor on any deck that is not completely closed and covered with a permanent deck above; neither shall they be carried in tiers above a compartment where other animals are carried, nor in any part of the vessel where they would interfere with the proper management or ventilation of the vessel.

Space.—Sufficient space shall be provided in every pen to enable the animals therein properly to feed and rest during the voyage, the minimum space per head being 2 feet 6 inches in width for fat cattle and 2 feet in width for store cattle under 1,000 lbs. weight. No pen shall exceed 11 feet in length (fore and aft) and 9 feet in breadth, and its construction shall be of such character and strength as to be able to withstand the action of the weather

and the weight of the animals thrown against it The floors of pens and gangways to be fitted with battens or other proper footholds.

There shall be a continuous fore and aft gangway at least 3 feet wide between every two rows of animals and an athwartship passageway at least 18 inches wide communicating with the fore and aft passageway in each compartment.

The compartments shall be efficiently ventilated by electric fans or otherwise of sufficient capacity entirely to change the air once every three minutes, and the compartments to be adequately lighted.

All cattle to be securely tied by the head or neck in such manner as not to cause unnecessary suffering and so as to stand athwartships facing the passageways.

Gangway doors not less than 5 feet 6 inches in height and 3 feet 9 inches in width shall be fitted in the ship's side above the main deck, so placed that the animals can be driven direct across the deck clear of hatchways or other obstruction.

Every consignment to be under the charge of a responsible foreman with competent assistants, numbering, with himself, three attendants for every 100 head of cattle. Proper accommodation for all these persons shall be provided.

The master of every ship carrying cattlemen from overseas to a port in the United Kingdom shall furnish to the Immigration Officer immediately on arrival particulars with regard to any cattlemen carried, their name, nationality and proposed address.

Every vessel shall carry an approved killing instrument to slaughter seriously injured animals. A record of casualties shall be kept stating how many animals died or were killed or injured on the voyage and the cause of such death.

The Schedules to the Order specify in detail the dimensions to be observed in the construction of pens and fittings for the protection of animals. Cattle pens, for example, are 8 ft. $\times$ 2½ ft. $\times$ 7 ft. (140 cubic feet), but four are usually carried in a 10-ft. stall in regular cattle boats.

"The Specification for Fitting Ships for the Conveyance of Horses or Mules" is issued by the Sea Transport Department, Board of Trade.

THE FACTORY AND WORKSHOPS ACT.

The requirements of this Act are supervised by surveyors appointed by the Home Office. The part of the Act applying to ships comes under Dock Regulations, copies of which are exhibited within the precincts of harbours and on board ships. Penalties are imposed on employers, employees and other persons who contravene or fail to comply with the Regulations. Nautical officers should be conversant with the requirements, and we here refer to some of the more important that are likely to come within their province.

The United Kingdom Steamship Assurance Association in a report under the heading "Loss of Life and Personal Injury," remarked that "the most frequent causes of accidents on board ship are defective hatch covers resulting in men falling into ships' hold and defective gear. If only ships' officers would guard against these two things probably 25 to 50 per cent. of the deplorable accidents could be prevented."

Gangways.—When a ship is loading or discharging cargo or bunkers at a wharf, a gangway shall be provided for the safe means of access of authorised persons, and when alongside other vessels or barges the ship with the higher freeboard shall provide the gangway.

The gangway has to be at least 22 inches wide, properly secured and fenced throughout on each side to a clear height of $2\frac{3}{4}$ feet by means of upper and lower rails, taut ropes or chains, or by other equally safe means.

Access to holds, unless permanent footholds are fitted according to prescribed regulations, shall be by means of ladders, and these are only to be deemed safe when the cargo is stowed far enough from the ladder to have at each of its rungs sufficient room for a man's feet. All parts of the ship to which persons employed may be required to proceed in the course of the employment shall be sufficiently lighted, subject to the safety of the ship, her cargo, navigation, or to bye-laws or regulations of Harbour Authority.

Hatches.—Portable hatch beams to have suitable gear for lifting them. Hatch beams and covering to be plainly marked for the position they belong, and adequate hand grips to be fitted on all hatch coverings. A hatch is defined as an opening in the deck used

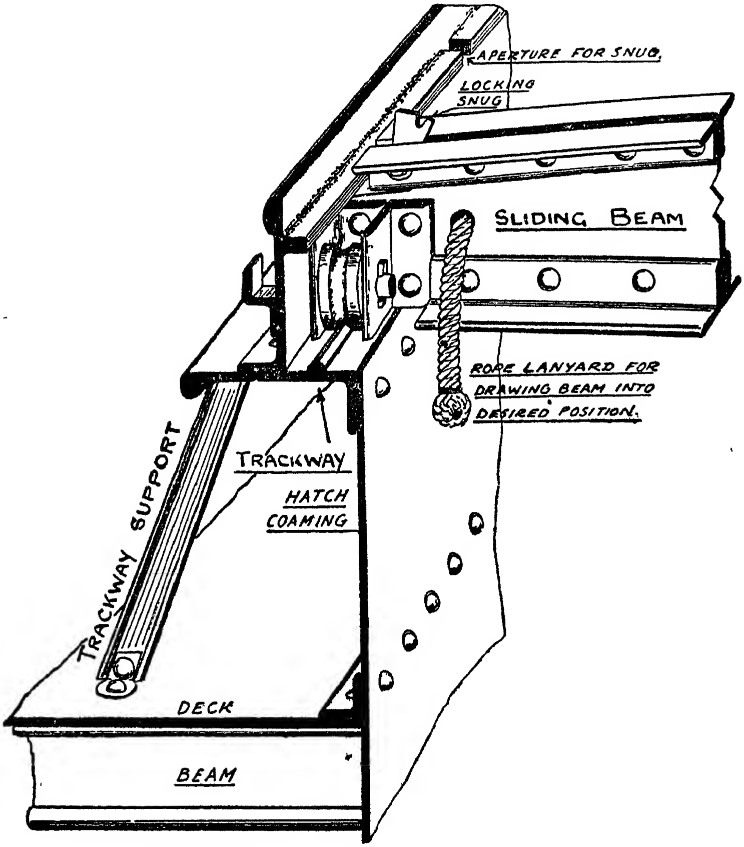


Fig. 4 shows the "T" and "B" Patent Sliding Hatch Beam.

Time is saved and accidents avoided when this beam is fitted, as it need not be unshipped but simply pushed by hand forward or aft to any desired position as indicated in the illustration.

for the purpose of handling cargo, for trimming, or for ventilation, and the coamings are less than 2 feet 6 inches in height; such hatches shall either be fenced to a height of 3 feet or be securely covered. Hatch coverings shall not be used in the construction of deck or cargo stages, or for any other purpose which may expose them to damage.

No person shall, unless duly authorised or in case of necessity, remove or interfere with any fencing, gangway, gear, ladder, *hatch*

covering, life-saving means or appliances, lights, marks, stages or other things whatsoever required by these Regulations to be provided. If removed, such things shall be restored at the end of the period during which their removal was neecssary by the persons last engaged in the work that necessitated such removal

The fencing required by the Regulations shall not be removed except to the extent and for the period reasonably necessary for carrying on the work of the dock or ship, or for repairing any fencing. If removed it shall be restored forthwith at the end of that period by the persons engaged in the work that necessitated its removal.

Every *person employed* shall use the means of access provided in accordance with the Regulations, and no person shall authorise or order another to use means of access other than those provided in accordance therewith.

No person shall go upon the fore and aft beams or thwartship beams for the purpose of adjusting the gear for lifting them on and off nor shall any person authorise or order another to do so.

LIFTING GEAR.

(*a*) All *lifting machinery* shall have been tested and examined by a competent person in the manner set out in the Schedule to these Regulations before being taken into use.

(*b*) (i.) All derricks and permanent attachments, including bridle chains, to the derrick, mast and deck, used in hoisting or lowering shall be inspected once in every twelve months and be thoroughly examined once at least in every four years.

(ii.) All other *lifting machinery* shall be thoroughly examined once at least every twelve months.

(iii.) For the purposes of this Regulation thorough examination means a visual examination, supplemented if necessary by other means such as a hammer test, carried out as carefully as the conditions permit, in order to arrive at a reliable conclusion as to the safety of the parts examined ; and if necessary for the purpose, parts of the machines and gear must be dismantled.

(*a*) No chain, ring, hook, shackle, swivel or *pulley block* shall be used in hoisting or lowering unless it has been tested and examined by a competent person in the manner set out in the Schedule to these Regulations.

(b) All chains, other than bridle chains attached to derricks or masts, and all rings, hooks, shackles and swivels used in hoisting or lowering shall, unless they have been subjected to such other treatment as may be *prescribed*, be effectually annealed under the supervision of a competent person and at the following intervals :--

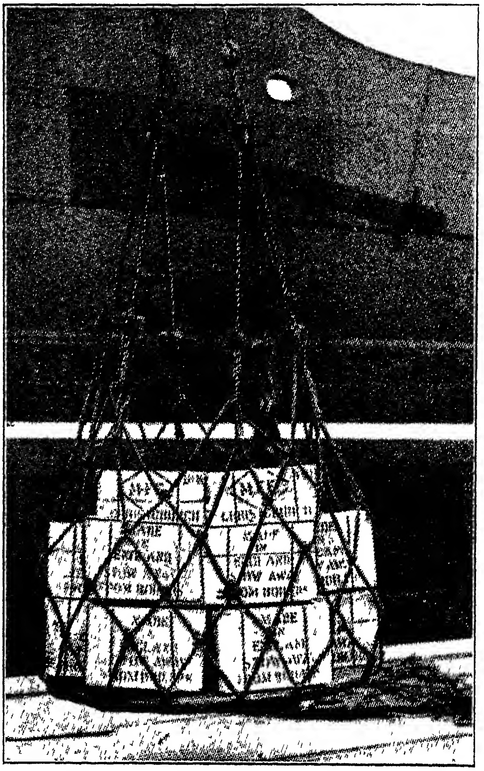


Fig. 5.
A netboard for lifting small cased goods up to a maximum weight of 25 cwt.

(i.) half inch and smaller chains, rings, hooks, shackles and swivels in general use, once at least in every six months;

(ii.) all other chains, rings, hooks, shackles and swivels in general use once at least in every twelve months.

(a) No rope shall be used in hoisting or lowering unless—

(i.) it is of suitable quality and free from patent defect, and

(ii.) in the case of wire rope, it has been examined and tested by a competent person in the manner set out in the Schedule to these Regulations.

(*b*) Every wire rope in general use for hoisting or lowering shall be inspected by a competent person once at least in every three months, provided that after any wire has broken in such rope it shall be inspected once at least in every month.

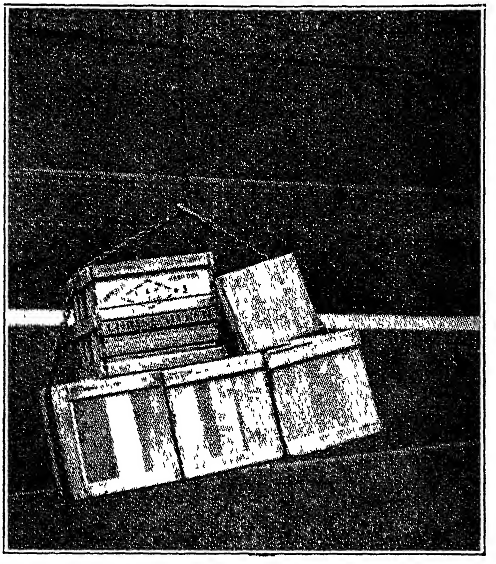


Fig. 6.
A chain sling with hook. $\frac{1}{2}$ inch link, 16 to 24 feet long for slinging cases. Maximum safe working load 6d² tons, where "d" is the diameter (in inches) of the iron of which the links are made.
$6 \times \frac{1}{2}'' \times \frac{1}{2}'' = 1\frac{1}{2}$ tons.

(*c*) No wire rope shall be used in hoisting or lowering if in any length of eight diameters the total number of visible broken wires exceeds ten per cent. of the total number of wires, or the rope shows signs of excessive wear, corrosion or other defect which, in the opinion of the person who inspects it, renders it unfit for use.

(*d*) A thimble or loop splice made in any wire rope shall have at least three tucks with a whole strand of the rope and two tucks with one half of the wires cut out of each strand. The strands in all cases shall be tucked against the lay of the rope. Provided that

this Regulation shall not operate to prevent the use of another form of splice which can be shown to be as efficient as that laid down in this Regulation.

No *pulley block* shall be used in hoisting or lowering unless the safe working load is clearly stamped upon it.

Means shall be provided to enable any person using a chain or wire rope sling to ascertain the safe working load for such chain or sling under such conditions as it may be used.

(*a*) As regards chain slings, such means shall consist of marking the safe working load in plain figures or letters upon the sling or upon a tablet or ring of durable material attached securely thereto.

(*b*) As regards wire rope slings, such means shall consist of either the means specified in paragraph (*a*) above or a notice or notices, so exhibited as to be easily read by any person concerned, stating the safe working loads for the various sizes of wire rope slings used.

Chains shall not be shortened by tying knots in them; and suitable packing shall be provided to prevent the links coming into contact with sharp edges of loads of hard material.

SAFETY PRECAUTIONS.

All motors, cog-wheels, chain and friction gearing, shafting, live electric conductors and steam pipes shall (unless it can be shown that by their position and construction they are equally safe to every *person employed* as they would be if securely fenced) be securely fenced so far as is practicable without impeding the safe working of the ship and without infringing any requirement of the Board of Trade.

Adequate measures shall be taken to prevent exhaust steam from, and so far as is practicable live steam to, any crane or winch obscuring any part of the decks, gangways, stages, wharf, or quay where any person is employed in the *processes*.

Appropriate measures shall be taken to prevent the foot of a derrick being accidentally lifted out of its socket or support.

Precautions shall be taken to facilitate the escape of the workers when employed in a hold or on 'tween decks in dealing with coal or other bulk cargo.

When the working space in a hold is confined to the square of the *hatch*, hooks shall not be made fast in the bands or fastenings of bales of cotton, wool, cork, gunny bags or other similar goods, nor shall can hooks be used for raising or lowering a barrel when, owing to the construction or condition of the barrel or of the hooks, their use is likely to be unsafe.

Nothing in this Regulation shall apply to breaking out or making up slings.

When work is proceeding on any skeleton deck, adequate staging shall be provided unless the space beneath the deck is filled with cargo to within a distance of two feet of such deck.

Where stacking, unstacking, stowing or unstowing of cargo or handling in connection therewith cannot be safely carried out unaided, reasonable measures to guard against accident shall be taken by shoring or otherwise.

The beams of any *hatch* in use for the *processes* shall, if not removed, be adequately secured to prevent their displacement.

When cargo is being loaded or unloaded by a fall at a *hatchway*, a signaller shall be employed, and where more than one fall is being worked at a *hatchway*, a separate signaller shall be employed to attend to each fall.

Provided that this Regulation shall not apply in cases where a barge, lighter or other similar vessel is being loaded or unloaded if the driver of the crane or winch working the fall has a clear and unrestricted view of those parts of the hold where work is being carried on.

When any *person employed* has to proceed to or from a ship by water for the purpose of carrying on the *processes*, proper measures shall be taken to provide for his safe transport. Vessels used for this purpose shall be in charge of a competent person, shall not be overcrowded, and shall be properly equipped for safe navigation and maintained in good condition.

There are various registration forms issued by the Home Office to be filled in when winches, derricks, cargo blocks and gear have been inspected. Particulars of the testing of any chain, ring, hook, shackle or swivel, or any pulley, gin or block, is given on the certificate granted by the firm authorised by the Home Office to carry out such tests, the maximum safe working load of the several items being specially mentioned. This certificate remains in force until the next annual examination and annealling of chains, etc., is called for.

SCHEDULE.

Manner of Test and Examination before taking Lifting Machinery and Gear into Use.

(a) Every winch with the whole of the gear accessory thereto (including derricks, goosenecks, eye-plates, eye-bolts or other attachments) shall be tested with a proof load which shall exceed the safe working load as follows :—

Safe working load.	*Proof load.*
Up to 20 tons.	25 per cent. in excess.
20-50 tons.	5 tons in excess.
Over 50 tons.	10 per cent. in excess.

The proof load shall be applied either (i) by hoisting movable weights or (ii) by means of a spring or hydraulic balance or similar appliance, with the derrick at an angle to the horizontal which shall be stated in the certificate of the test. In the former case, after the movable weights have been hoisted, the derrick shall be swung as far as possible in both directions. In the latter case, the proof load shall be applied with the derrick swung as far as practicable first in one direction and then in the other.

(b) Every crane and other hoisting machine with its accessory gear shall be tested with a proof load which shall exceed the safe working load as follows :

Safe working load.	*Proof load.*
Up to 20 tons.	25 per cent. in excess.
20-50 tons.	5 tons in excess.
Over 50 tons.	10 per cent. in excess.

The said proof load shall be hoisted and swung as far as possible in both directions. In the case of a jib-crane, if the jib has a variable radius, it shall be tested with a proof load as defined above at the maximum and minimum radii of the jib. In the case of hydraulic cranes or hoists where, owing to the limitation of pressure, it is impossible to hoist a load 25 per cent. in excess of the safe working load, it shall be sufficient to hoist the greatest possible load.

(c) Every article of loose gear (whether it is accessory to a machine or not) shall be tested with a proof load at least equal to that shown against the article in the following table :—

Article of Gear.	*Proof load.*
Chain	Twice the safe working load.
Ring	Twice the safe working load.
Hook	Twice the safe working load.
Shackle	Twice the safe working load.
Swivel	Twice the safe working load.
Pulley Blocks :	
Single Sheave Block	Four times the safe working load.
Multiple Sheave Block with safe working load up to and including 20 tons	Twice the safe working load.

Multiple Sheave Block with safe working load over 20 tons up to and including 40 tons	20 tons in excess of the safe working load
Multiple Sheave Block with safe working load over 40 tons . .	One and a half times the safe working load.

Provided that where the Chief Inspector of Factories is of opinion that, owing to the size, design, construction, material or use of any such loose gear or class of such gear, any of the above requirements are not necessary for the protection of *persons employed*, he may by certificate in writing (which he may in his discretion revoke) exempt such gear or class of gear from such requirement subject to such conditions as may be stated in the certificate.

(*d*) After being tested as aforesaid, all machines with the whole of the gear accessory thereto and all loose gear shall be examined, the sheaves and the pins of the *pulley blocks* being removed for the purpose, to see that no part is injured or permanently deformed by the test.

(*e*) In the case of wire ropes, a sample shall be tested to destruction and the safe working load shall not exceed one-fifth of the breaking load of the sample tested.

CLASSIFICATION SURVEYS.

To receive the distinctive mark 100 A1 in Lloyd's Register, the vessel must be surveyed periodically. Surveys become due at 4 years (No. 1 Survey), 8 years (No. 2 Survey) and 12 years (No. 3 Survey) from the date of build, a year's grace being permitted in which to complete the survey. The conditions of survey are as follows :—

SPECIAL SURVEY No. 1.

1. The vessel is to be placed on blocks of sufficient height in a dry dock, or on a slipway ; proper stages are to be made, and the holds and peaks are to be cleared for examination.

2. In vessels having a single bottom the limber boards and ceiling equal to not less than two strakes fore and aft on each side are to be removed, one such strake being taken from the bilges. Where the ceiling is fitted in hatches, the whole of the hatches and one strake of ceiling at the bilges are to be removed.

3. The coal bunkers of steam vessels are to be cleared for examination, and ceiling is to be removed as in the holds. The bilges and limbers all fore and aft are to be cleaned out, so as to allow of these parts being properly examined.

4. The framing and both surfaces of shell plating are to be

exposed, and cleaned and coated where necessary. Special attention should be given to the examination of the ash shoots, and the shell plating in way of the openings.

5. In cases in which the inner surface of the bottom plating is coated with cement or asphalt, the removal of this coating may be dispensed with, provided it be carefully inspected, tested by beating or chipping, and found sound and adhering satisfactorily to the steel.

6. If the vessel has a double bottom a sufficient amount of ceiling is to be removed to enable the condition of the tank top to be ascertained, and if it is found that the plating is free from dirt and rust, the removal of the remainder of the ceiling may, in the case of the First Special Survey, be dispensed with.

7. The double bottom tanks are to be tested by a head of water to the light water-line, but in no case less than 8 feet above the inner bottom. Double bottom compartments, which are used for the carriage of oil fuel, are to be tested by a head of water extending to the load water-line, or by a head sufficient to give the maximum pressure which can come upon them in practice, whichever is the greater.

Where peak tanks or other deep tanks for carrying water ballast are fitted, their watertightness is to be tested by a head of water not less than 8 feet above the crown of the tank.

All water ballast tanks are to be cleaned out to admit of their being properly examined inside, special attention being given to the tanks under the boilers.

All peak tanks, deep tanks and bunkers specially constructed for carrying oil fuel are to be examined internally and are to be tested by a head of water equal to 30 per cent. of the depth of the tank, or 8 feet, whichever is the greater, provided the tanks are fitted with overflows or other means to prevent a greater pressure than indicated above. Where the tanks are not fitted with overflows or other similar devices, they must be tested by a head sufficient to give the maximum pressure which can be experienced in practice.

In the case of motor and other vessels burning oil fuel and carrying it in the double bottom and other tanks, upon the occasion of the First Special Survey No. 1 these tanks, with the exception of

the fore and aft peak tanks, need not be examined internally, provided upon a general external examination of the tanks the Surveyor finds their condition to be satisfactory. In these cases the tanks are to be tested by a head of water of not less height than that stated above.

8 When a deck originally required to be 3 inches thick is worn to $2\frac{1}{2}$ inches, $2\frac{1}{2}$ inches to 2 inches, it is to be renewed. If, however, such deck is found on survey to be in good condition the case will, upon application, receive the consideration of the Committee.

9. The masts, spars, rigging, anchors, and general equipment of steam and sailing vessels are to be examined and either found, or placed, in good and efficient condition.

10. The hatch covers and supports throughout are to be examined in position at the hatchways, and, if defective, are to be renewed or made good.

The Surveyors should report on the efficiency of the tarpaulins, cleats, and battens, or other means of securing the hatches.

The ventilator coamings and covers are to be examined, and special care is to be taken to see that they are in an efficient condition.

11. The steering engine and its connections, the telemotor gear, the steering rods, chains, blocks, rudder, quadrant, tiller, steering gear, windlass, pumps, sluice valves, watertight doors, and air and sounding pipes are to be carefully examined, and their condition is to be stated on the Surveyor's report.

The Surveyor is to see that doubling plates are fitted under all sounding pipes.

12. Where holds are insulated for the purpose of carrying frozen or chilled meat, and the vessel in way of the insulation was examined by the Society's Surveyors at the time such insulation was fitted, it will be sufficient at the first Special Survey No. 1 to remove the limbers and hatches to enable the plating to be examined.

13. The freeboard recorded in the Register Book is to be verified.

14. The main and auxiliary engines and boilers are to be examined and favourably reported on by the Society's Engineer Surveyors.

SPECIAL SURVEY No. 2.

Survey No. 2 is the same as for Survey No. 1 and in addition—

The plating in way of the side-lights is to be examined, and if the Surveyor deems it necessary he may require holes to be drilled in any portion of the structure where signs of wastage are evident.

The chain cables are to be ranged for inspection, and the anchors and chains are to be examined and placed in good working order. If any length of cable is found to be reduced in mean diameter at its most worn part it is to be renewed. The chain locker is to be examined internally.

SPECIAL SURVEY No. 3.

All the requirements of Survey No. 1 and No. 2 have to be complied with, and in addition all rust is to be removed from iron and steel work throughout the ship, and the Surveyor is to satisfy himself as to the condition of the plating which may, if considered necessary, be drilled to test for thickness at places indicated by him, afterwards all scaled and chipped parts to be coated.

All iron, steel and wooden masts, derricks, etc., are to be tested by hammering, and, if considered necessary, drilled to test for thickness of plating, etc. Mast wedges to be removed and replaced.

Where holds are insulated, inspection holes in the insulation to be cut and frames and plating in the way of same to be examined.

The Machinery Survey is carried out periodically at the same time as the hull survey. Boilers, however, when they are six years old come under an annual survey.

The Steam Steering Engine and its connections, the steering rods, chains, blocks, rudder, quadrant, tillers, steering gear, windlass pumps, sluice valves, watertight doors, air and sounding pipes are to be carefully examined, and the condition of same is to be stated on the Surveyor's report. The Surveyor must see that the doubling plates are fitted under all sounding pipes.

Double Bottom Tanks.—The ceiling of double bottom is removed and the efficiency of the tanks tested by a head of water to the height of the load waterline. Peak tanks and deep ballast tanks are tested by a head of water not less than 8 feet (or 30 per

cent. of depth of tank, whichever is greater) above the crown of the tank. See remarks on water pressure on pages 363 to 372.

Subsequent Surveys.—The Second No. 1, No. 2 and No. 3 Surveys are due, respectively, when the vessel is 16, 20 and 24 years old, and the inspection increases in rigorousness with the age.

SHIPPING OFFICE ROUTINE.

ENGAGEMENT OF CREW.

The master must produce the certificates of himself and such of his officers, engineers and crew as require them, also the ship's Freeboard Certificate and Certificate of Registry.

The Articles must be dated and signed first by the master.

The Articles of Agreement (Form Eng. 1) must be in a form approved by the Board of Trade, and two copies are signed—one is retained by the superintendent, the other the master takes with him.

The Agreement must specify the following particulars:—

(*a*) The nature, and as far as practicable, the duration of the voyage, maximum period of engagement, and ports or places to which the voyage is not to extend, and the limits of latitude.

(*b*) The number and description of crew, and how many are engaged as sailors.

(*c*) Time at which each seaman is to be on board, or to begin work.

(*d*) Capacity in which each is to serve.

(*e*) Scale of provisions.

(*f*) Regulations as to conduct on board, fines, etc., for misconduct.

When the crew are duly engaged the superintendent issues to the master a certificate which the master must produce at the Custom House when clearing his ship outwards. This certificate is the A.A. in the case of foreign going vessels, and the C.C. for home trade vessels.

The master also receives the Official Log, a copy of the Articles, the Return List (or Form Eng. 2), Abstract of Articles for placing

on board in a place accessible to the crew, Wages Account Forms, and National Health Insurance Schedules

The Form Eng. 2 must, before finally leaving, be filled up and sent to the nearest superintendent. It shows the changes made in the crew (if any) since signing articles, and the names of those shipped as substitutes for those who have not joined.

Penalty for failing to comply with this part of the Act, a sum not exceeding £5.

Apprentices do not sign the Articles of Agreement, they are bound to the shipowner for the period of their apprenticeship, but their indentures are produced at the Shipping Office when the crew sign on, and their names, ages, etc., entered on the Articles. Failure to do so involves a penalty not exceeding £5.

Cadets, however, sign the Articles, as their agreement is for the voyage only, just the same as other members of the crew.

Failure to Join.—Where a seaman has been duly engaged, but after receiving and cashing an advance note wilfully or through misconduct fails to join or deserts his ship before the note becomes payable, he is liable to a fine of £5 or 21 days' imprisonment. The seaman gets someone to advance to him the amount of money therein stated and to endorse the note to that effect. The person who advances the money is repaid by the shipowners on presenting the note so many days, usually three, after the ship has sailed, provided, of course, that the seaman goes in the ship.

Articles for more than One Voyage.—Coasting Articles for home trade ships and Running Agreement Articles for vessels on short voyages to ports situated just beyond home trade limits may be opened to avoid the delay of paying off and signing on again at frequent intervals. Such articles do not extend for a period exceeding six months and terminate automatically on the last day of June and December, three weeks' grace being allowed in which to return them to the Mercantile Marine Office.

The home trade applies to vessels trading within the following limits:—The United Kingdon, the Channel Islands, the Isle of Man, and the Continent of Europe between the River Elbe and Brest inclusive.

Certificated Officers.—Certification of officers and engineers in home trade cargo ships is not compulsory, but all foreign-going

vessels and home trade passenger vessels must carry a duly certificated master; and all such vessels of 100 tons burden and upwards must also carry a duly certificated mate in addition to the master. Foreign-going vessels carrying more than one mate must have at least the first and second mates duly certificated.

Foreign-going steamships of 100 N.H.P. or upwards must have at least two engineers, one first class and one second class, duly certificated, and foreign-going steamships and home trade passenger vessels of less than 100 N H.P. must have at least one certificated engineer.

DISCHARGING THE CREW.

The master must pay to each seaman, on the lawful termination of his engagement, two pounds (£2), or one quarter of the amount of wages due to him, whichever is least. The crew to be paid off within two clear days (Sundays, holidays, etc , not counted).

The master must deposit the Articles and Official Log within 48 hours of arrival; or when paying the crew off, if that takes place within 48 hours.

On the satisfactory closing of the Articles the superintendent must deliver to the master a certificate to that effect (the B.B.).

The B.B. must be produced to the officer of Customs when the ship is cleared inwards (see Custom House Regulations).

Dispute on Paying Off.—Any question of whatever nature and whatever the amount in dispute between a master or the owner and any of his crew if raised before a Superintendent of a Mercantile Marine Office, and both parties agree in writing to submit the same to him. The Superintendent shall hear and decide the question submitted, and his decision shall be conclusive.

Seaman left behind in Hospital.—The man's wages and effects, together with a list of same in duplicate, one for the patient and one for the Consul, are handed to the British Consul and sufficient money is left to cover all the man's expenses. This is all carefully recorded in the Official Log. The British Consul attends to the repatriation of the man when he is discharged from hospital.

Ship Abandoned.—In the event of shipwreck the crew are entitled to two months' pay from the date of abandonment, unless

they are offered and accept equivalent employment in another ship.

Period of Agreement Expiring Abroad.—If the date of termination of the Articles of Agreement occurs when the vessel is abroad, the Consul may grant an extension of the period, but if not it then becomes a question of a mutual agreement between the master and the crew regarding rate of wages. Failing an agreement on the point, the crew must be repatriated and wages paid up to the date of their arrival home.

Deserters.—A seaman is said to be a deserter when he unjustifiably leaves a ship in the course of a voyage or engagement without having been discharged and with the intention of not returning

In the event of any of the crew deserting the ship, notice should at once be given to the Local Authorities (Police) with a full description of the men and any other useful information having a view to their arrest and return to ship. In many places the ship is liable to a heavy fine if they remain ashore.

Take the Articles to the Shipping Master or Consul and have them endorsed with a certification that the *reason* of the men being left behind is desertion. This is very important, as otherwise the deserter will probably become classed as a "distressed seaman" and as such the owner will become liable for repatriation expenses.

Make an entry in the official log book of the fact and details of the desertion, also a list of the effects left on board and the amount due on account of wages.

Deserters forfeit all the wages they have earned and any effects they may leave on board. Their effects must be handed over to the Superintendent of a Mercantile Marine Office at the end of the voyage within 48 hours of arrival, also their wages less all expenses incurred in engaging substitutes. These expenses must be set out in a "re-imbursement" account form provided by the Board of Trade, and should be supported by vouchers whenever possible. In this account may also be included the amount paid to the substitutes beyond what the deserters would have earned.

The Consul may order the effects left behind by deserters in a foreign port to be sold, in which case the amount realised, less the expense incurred, is handed to the Consul. The master or owners

are entitled to be re-imbursed for any sum properly chargeable against deserters, and the balance, if any, is paid into the Exchequer through the Board of Trade.

Joining the Navy.—If a seaman leaves his ship to enter the Naval Service forthwith and is accepted for such service, he is not deemed to be a deserter. The master shall deliver to him his effects and pay any balance of wages to the naval officer who receives the seaman, and who shall give the master a receipt for same. Should the seaman be in debt to the ship, the owner can recover the amount from the Accountant General of the Navy.

Distressed British Seamen.—British Consular officers and other officers of His Majesty in foreign countries are empowered to provide maintenance for distressed British seamen found abroad and to put them on board a British ship bound to the United Kingdom or to the British possession to which the seaman belongs.

But should a British ship in the port be in want of men to make up its full complement, the Consul should, of course, endeavour to ship the men back under "Articles" and not as distressed seamen.

The master of a British ship is bound by the Merchant Shipping Act to take on board his ship any distressed British seamen, but not necessarily more than one for every 50 tons burden, and to provide them with proper accommodation and food.

The master must make a sworn declaration giving all particulars of the men and the number of days they have been on board the vessel, the full complement of the ship's crew must also be stated. The owner is paid out of the Mercantile Marine Fund for every day the distressed seamen have been on board, but only for those distressed British seamen in excess of the normal complement of the ship.

OFFICIAL LOG.

The master is responsible for the Official Log being properly kept. The draught and freeboard must be entered whenever leaving port. A list of the entries required to be made is given at the beginning of the log book.

Amongst these the principal are :—

Offences committed by any member of the crew, or conviction by any legal tribunal.

Any offence for which punishment is inflicted on board, and the punishment.

The names, also a statement of the conduct, character, and qualifications of each member of the crew, or a statement that the master declines to give an opinion on these particulars.

Every case of illness; the treatment adopted, etc.

Every case of birth, death, or marriage.

Every change of crew during the voyage.

The amount of wages due to any seamen who enters His Majesty's service.

The wages account of any seaman or apprentice who dies during the voyage, including a statement of each article sold, and the amount received for it

Every collision with any other vessel.

A statement of every occasion on which boat drill is practised on board the ship, and on which the life-saving appliances on board have been examined to see if they are fit and ready for use. It must be shown to any officer of the B O.T. on demand. Penalty for infringement, £10.

When entries are made in the Official Log, they must be made as soon as possible after the occurrence to which they relate, and must be dated. Entries made in respect of an occurrence happening before the arrival at the final port of discharge must be made within 24 hours of arrival.

All entries must be signed by the master and by the mate, or some other member of the crew.

In the event of disrating or penalising a member of the crew for incompetency or misconduct, the entry in the Official Log must be read over to him and a copy of the entry must be given to the man. The amount of any fines imposed must be paid over to the Superintendent of the Mercantile Marine Office.

The Official Log is returned to the Mercantile Marine Office on the termination of the Articles of Agreement; or on the transfer of ownership if the ship is abroad, or if the ship be lost or abandoned.

Death at Sea.—In the event of a member of the crew or a passenger dying at sea, the master must make a full and detailed entry in the Official Log Book, and, if there is not a qualified medical

man on board, he should describe the person's illness, or accident, as the case may be, the treatment adopted, etc., the exact time of death and the ship's position at the moment.

The entry to be signed by the Chief Officer and by some of the friends of the deceased person, especially by any of the men who had been detailed to look after him. The ship should be stopped and Christian burial conducted.

The property and money due to a deceased seaman is delivered to the Superintendent of a Mercantile Marine Office within 48 hours of ship's arrival at a home port. But if the effects are sold on board by public auction an accurate entry giving the following particulars must be made in the Official Log and duly signed by an officer and a member of the crew.

(*a*) A statement of the amount of the money and a description of the effects.

(*b*) A description of each article sold and the sum received for each.

(*c*) A statement of the sum due to the deceased for wages and the amount of deductions (if any) to be made from the wages.

CASUALTIES.

"**Courts of Enquiry.**"—In the event of a shipping casualty, the Board of Trade usually hold a preliminary inquiry on the result of which the Board may order a formal investigation into the circumstances to be held before a Commissioner of Wrecks, who will be assisted by nautical assessors appointed by the Home Office.

The Legislature of any British possession has also power to authorise a tribunal to make inquiries as to shipwreck or other casualties affecting ships, or as to charges of incompetency or misconduct of masters, mates and engineers.

"**A Naval Court**" may be summoned by a commanding naval officer on any foreign station, or by a Consular officer, whenever a complaint of serious breaches of discipline which appears to that officer to require immediate investigation is made to him by the master of a British ship, or officers or members of the crew; whenever the interest of the owner or of the cargo thereof appears to

require it; and into any cases of the wreck or abandonment of a vessel.

The Naval Court must be properly constituted, and shall consist of at least three members, one of whom shall be a naval officer not below the rank of Lieutenant, one a Consular officer, and one a British shipmaster.

These several courts have similar powers and may cancel or suspend the certificates of masters, mates and engineers, remove any members of the crew, impose fines and punishment for misdemeanours; in short, all the powers of a court of summary jurisdiction.

"**A Court of Survey**" consists of a judge or magistrate and two assessors, either nautical or engineer, or persons having special qualifications to investigate the question at issue.

The Court deals with complaints regarding the seaworthiness of the vessel and her equipment and cargo, and has powers to order the inspection of every part of the ship, the removal of her cargo, and to detain or release the ship as the court may decide.

A ship may be "unseaworthy" in ways other than that of structural weakness; for example, a ship having masters or officers without the necessary qualifications, or being undermanned, or being short of bunker coals, provisions, stores or any part of the usual and necessary equipment, is not in "every way fitted for the voyage" and is therefore technically "unseaworthy."

The cases which most frequently come before courts of summary jurisdiction in this country are breaches of the Regulations of the Factory Act as applicable to the loading and discharging of cargo; failure to comply with the requirements of medical officers *re* crews' quarters, etc.; throwing refuse overboard within the limits of a port; oil pollution of harbours; overloading; carrying an excessive or improper deck load; smuggling by members of the crew, etc.

CHAPTER XX.

SHIP'S BUSINESS.

Modern shipping business is transacted with greater rapidity than formerly due to the development of telegraphic communication between ships at sea and land stations, thus enabling the owner to keep in constant touch with the shipmaster so, nowadays, it is seldom that the master of a ship is called upon to transact business as if he were the sole representative of the ship completely cut off from the shipowner, consignees or agents, and acting on his own initiative. Most of the business is done by the owners' authorised agents, who make the necessary arrangements pending the ship's arrival, and often complete the essential documents after she has sailed. This is particularly the case in cargo liners owned by firms that grant through bills of lading from the place of origin to destination, no matter how far inland they may be, the forwarding business being transacted by the owners' agents at the various places of transfer where the goods may be handled. But the system of examination in the commercial and legal duties of shipmasters assumes that the candidate is not merely master of the vessel but, in effect, the owner also, and, as such, he is expected to approach all matters connected with the transaction of the ship's business, whether it be of an ordinary or of an extraordinary character, with prescience, and to act to the best of his ability as if the ship and cargo were uninsured and belonged solely to himself.

Every shipmaster should have a copy of the Merchant Shipping Act at hand for reference in cases of doubt or difficulty.

For convenience of reference the following subjects have been arranged in alphabetical order :—

A. A.—A certificate given to the master of a foreign-going vessel by the superintendent of the shipping office. It certifies that the master has engaged his crew and has produced the ship's register, his certificate, officers' and engineers' certificates, load line certificate,

apprentices' indentures, etc. The A A. has to be produced at the Custom House for clearance outwards.

Advance Notes.—The Merchant Shipping Act provides that a seaman may, conditionally on his going to sea in pursuance of his agreement, receive an advance note for a sum not exceeding the amount of one month's wages. Note that this is different to an "allotment" note. The seaman cannot *claim* an advance note if the master desires to withhold it.

Allotment Notes.—A seaman may claim an allotment note of any part (not exceeding one-half) of his wages in favour either of a near relative or a savings bank. The Superintendent or other officer before whom the seaman is engaged, shall, after the seaman has signed the agreement, inquire if he wishes to have an allotment note; and, if he does, shall insert such fact in the agreement with the crew, and it shall be deemed to have been agreed to by the master.

The master has the option of advancing cash and granting shore leave in a foreign port, and should a seaman want to send home part of his wages and the master decides to grant him facilities for doing so, then the master may give him a note on the owners for the amount, enter it in the man's account of wages, and get his receipt for it.

Average.—There are two kinds of average, "Particular" and "General."

Particular Average represents an accidental loss arising from some peril insured against, such as loss of masts or spars through stress of weather, damage to hull or machinery through fire, collision, or stranding, etc.

Particular average losses are borne by the parties on whom they fall; that is, there is no general contribution by all concerned. In the case of an accident affecting the ship only, the cargo owners do not contribute, and *vice versa.*

Particular average losses are not recoverable from the underwriters unless they amount to 3 per cent. on the value insured. Shipowners, however, usually cover small damage up to 3 per cent. by insuring in Mutual Clubs and Protection Associations, the members' contributions being collected by "calls" on the ship-

owners, the amount being determined annually by the total tonnage of the ships owned by the firm and the extent of the claims paid by the Mutual Insurance Association.

General Average arises when some loss or expense has been wilfully and voluntarily incurred in order to save the ship and cargo, or what remains of them. It is termed "General," because the loss is borne generally by all interested in the ship, freight and cargo, each one's share of the loss being proportioned to the value he had at stake.

York-Antwerp Rules.—These form a code of rules for the settlement of cases of General Average, and are now universally adopted. They only apply, however, when expressly agreed upon in the charter-party and bills of lading. Where this is not done the average would be settled according to British law, which differs from the York-Antwerp Rules in one or two respects.

The Rules define broadly what may or may not be made good under general and particular average, and they serve as a guide to average adjusters in deciding how the various interests involved in the venture shall contribute their financial share of the loss.

The rules are recorded under the headings of :—Damage to ship and cargo in consequence of jettisoning cargo. Jettison of deck cargo is not made good as general average.

Extinguishing fire on shipboard and the resultant damage by fire and water.

Cutting away wreck.

Voluntarily running the ship ashore to avoid total loss or greater damage.

Damage to engines in the endeavour to refloat.

Expenses incurred in lightening a ship when ashore.

Cargo and material burnt for fuel if ship runs short of bunkers through unforeseen circumstances.

Expenses at port of refuge in discharging, storing and reloading cargo and damage to cargo during the process.

Wages and maintenance of crew in port of refuge.

Loss of freight, etc.

Average Adjuster is one whose special business it is to make out and draw up statements of general average, showing the amounts

payable by each party. The appointment of the average adjuster lies with the shipowner or master.

Average Bond.—This is an agreement between the master of a vessel and the consignees of the cargo, whereby they agree to pay to the master their respective proportion of the average when adjusted. The shipowner is entitled to require a deposit in advance, in addition to, or in place of the Average Bond.

Whenever a case of General Average arises, the master should get the Average Bond signed before delivering up the cargo, or see that proper security for the payment is obtained from the consignees.

Barratry.—Any illegal or fraudulent act wilfully committed by the master or any member of the crew to the prejudice of the shipowner. Examples—Smuggling without consent of owners; fraudulent dealing with ship and cargo; wilful resistance to a right of search; wilful breach of blockade; sailing from a port without leave in breach of an embargo.

B. B.—A certificate issued at the shipping office certifying that the master has deposited his "Articles" and Official Log Book with the Superintendent; has accounted for the whole of his crew; and, if any of the seamen have died, that he has settled the accounts for their wages and effects. The B.B. must be produced to the Customs Officer when the ship is cleared inwards.

Bill of Exchange.—A bill of exchange is an unconditional order in writing, addressed by one person or firm to another, requiring them to pay a certain sum of money to a person named on the bill, or to bearer. The bill may be made payable on demand, or at a certain number of days after sight.

(SPECIMEN.)

No. 9515. The Bank of London,
London, April 28, 1936.

Sixty days after sight of this **First** of Exchange (second and third of same tenor and date being unpaid), pay to the order of B. S. & F. two hundred pounds sterling value received.

For the Bank of London,
J. R. SMITH, *Manager*.

To the Bank of Adelaide,
Adelaide, S. A.

A bill of exchange which is payable at a fixed number of days after sight must be first **presented for acceptance.** The person or firm to whom it is addressed, if they accept it, will write the word "**accepted**" across the face of the bill, and duly sign and date the acceptance At the expiration of the specified number of sight days the bill is said to have matured, and is then payable. There are, however, always three days of grace allowed beyond the sight days, if required by the acceptors

An inland bill of exchange is one drawn and payable in the same country; any other is a foreign bill.

A bill of exchange which is payable on demand or at sight must be paid when presented, no days of grace being allowed in this case.

If the holder of a bill of exchange, payable at some future date, wishes to realise the money before that date, he can, *if the bill be a good one*, get it discounted; the banker who discounts it will pay him the money, minus the discount at the current rate of interest.

Bill of Health.—A document stating the health of the port with respect to infectious diseases at the time of the vessel's departure. There are three kinds: clean, suspected and foul.

British ships obtain their bills of health from the British Consul when leaving a foreign port, and from the Custom House when leaving a British port. It must be officially stamped or signed by the Consul of the country to which the ship is bound.

Bill of Lading.—A stamped document, usually signed by the master acknowledging the receipt on board of the goods described in the bill, and undertaking to deliver them at the port of destination. Requires a sixpenny stamp, which must *be an impressed and not an adhesive stamp*. It must be stamped before being signed. **Penalty for signing an unstamped bill of lading, £50.**

At the time of signing the bill of lading, the mate's receipt for the goods referred to in the bill should be produced, and the master should see that the bills accurately correspond to the mate's receipt before signing them. The mate's receipts should be preserved and retained by the master.

Generally (but not always) there are **three** bills of lading to a set. In all cases the number to be signed by the master is stated at the foot of the bills. An unstamped and unsigned copy is retained by the master for future reference.

The master should, before signing bills of lading, see that they are consistent with the charter-party, and that the interests of the ship are duly protected by the insertion of such clauses as may be necessary in respect of the nature of the goods

If the freight as per the bill of lading is less than that in the charter-party, the master should refuse to sign them unless the difference is made good in cash before signing This would not apply if the charter-party states that the master "is to sign bills of lading at any rate of freight without prejudice to the charter-party."

After reaching the port of destination the cargo must be delivered to the party presenting the bill of lading, duly indorsed by the shipper. The master should retain the indorsed bill of lading.

When writing out a set of bills of lading for signature, an extra copy is made out, but it is left unstamped and unsigned, and across it is written "Captain's Copy." This copy is carried in the ship for the captain's information, also to ensure that no fraudulent alteration has been made in the signed documents, and also for production on demand if boarded by a belligerent visiting officer.

Protective Clauses.—It is essential in dealing with the question of shortage, pillage and damage, that the general terms of the bill of lading is understood. A clean bill of lading is a shipowner's agreement to deliver the package in the same good order and condition as when received, and unless exception is taken to the package at shipment and the bill duly claused, the ship is responsible for any shortage or damage occurring. In loading cargo, therefore, the officers should keep a strict watch for cargo that is not in sufficiently sound condition to enable it to stand the stress of the voyage and handling, and then allow it to be delivered to the consignee intact.

Clauses can be added to the bills of lading in accordance with the mate's receipts and are a protection in the event of claims arising. Such clauses as frail package, renailed, unprotected, contents rattling, skeleton cases, dented, old bags, resewn bags, ullaged, contents leaking, rusty, stained and wet, etc., as the case may be.

The number of packages so queried should be specifically stated, giving the marks, numbers, etc., for identification purposes.

In bills of lading issued for optional ports the destination must

be declared by the consignee forty-eight hours before the vessel arrives at her first port, otherwise this cargo will be landed at the first port mentioned in the bill of lading, unless a special condition is attached to the bill.

Bottomry Bond.—A bill, by means of which a ship or the freight she earns is pledged in return and as security for money advanced.

A bottomry bond must only be raised when it is impossible to obtain credit, or to raise money by giving bills on the owners. It must be clearly a case where the money is necessary to enable the ship to proceed to her port of destination. Money advanced to the master on a bottomry bond *must only be expended on what is necessary for the continuance and completion of the voyage.*

More than one bottomry bond may be raised if circumstances arise rendering it necessary. The last raised must be repaid first.

If the ship is lost before reaching her port of destination, the lender loses the money advanced. If she arrives, he is repaid the amount, plus the agreed upon interest or premium.

C. C.—A certificate for the coasting trade, corresponding to the **A.A.** certificate for foreign-going vessels.

Charter-party.—A charter-party is a contract or agreement whereby a shipowner or master covenants for the use of the ship by the charterer for a specified voyage or time.

Special forms of charter-party are in use for particular trades or voyages ; but in all charter-parties the master or owner warrants the ship to be tight, staunch, and strong, and fitted for the voyage—*i.e.*, she shall be seaworthy.

The following are some of the principal points which generally appear in charter-parties :—

Freight Clause.—Stipulating the amount of freight, and when and how it is to be paid.

Lay Days or Hours.—The charter-party specifies the number of lay days or, in some cases, the number of hours, in which the cargo is to be loaded and discharged. It also specifies the kind of lay days or hours, *i.e.*, whether " working " or " running " days, etc. If " working " days, then all the days on which it is not usual to work, at the port where the ship is, are not counted. If " running " days, then every day counts. " Weather working " days are some-

times specified, and in others a definite date is fixed by which time the cargo is to be loaded.

Demurrage.—If the ship is not loaded or discharged at the expiration of the lay days, and delay arises from the fault of the charterer or his agents, the charter-party specifies that he must pay **a fixed sum per day or hour for the time the ship is detained. This payment is termed "demurrage."** It must be claimed daily, and the claim for Sundays must be made on Saturday. Generally the charter-party specifies the number of days during which a ship can be kept on "demurrage," and states that at the expiration of the demurrage days the ship is to be at liberty to sail, full or not full, and if not fully loaded the charterer is to pay "dead freight"* on the shortage. This, however, depends upon the actual wording of a charter-party

Despatch Money is the reverse of demurrage. It is a sum of money paid by the shipowner to the charterer for despatching the ship before the expiration of the lay days.

Floating Clause.—This stipulates that the ship shall proceed to her port of destination, or as near thereunto as she can safely get, where she can safely lay afloat at all times and tides.

Deviation from Voyage.—The charter-party specifies that the ship must proceed direct to her port of destination; that is, she must not deviate unnecessarily from her course.

Deviation and Towing Clause.—This is a clause usually inserted in steamers' charter-party, giving them liberty to tow or be towed, or to assist other vessels, and to deviate, if necessary, for this purpose. Without this clause a vessel would only be justified in standing by another in distress, in order to save life, and not with the view of earning salvage.

Exceptions or Negligence Clause.—By this clause the ship is excepted from responsibility for act of God, perils of the sea, fire, etc. The following negligence clause is copied word for word from a Welsh coal charter-party:—"The act of God, the King's enemies, restraints of princes and rulers, and perils of the seas excepted. Also fire, barratry of the master and crew, pirates, collisions, strandings and accidents of navigation, or latent defects

*See "Dead Freight."

in, or accidents to, hu and/or machinery, and/or boilers, always excepted, even when casioned by the negligence, default, or error in judgment of the pilot, master, mariners, or other persons employed by the shipowner, or for whose acts he is responsible, not resulting, however, in any case from want of due diligence by the owner of the ship, or by the ship's husband or manager."

Penalty Clause.—This clause specifies the penalty for non-performance. The usual penalty is proved damages not exceeding the estimated amount of freight.

If the ship is likely to have to discharge into lighters, there should be a clause specifying on whom the expense of lighterage is to fall

A charter-party requires a **sixpenny stamp** to make it legal.

An adhesive stamp may be used if affixed before signing, and must be cancelled by the last person signing.

A charter-party may be stamped with an impressed stamp, after being signed upon the following terms :—

1. Within seven days, on payment of duty and a penalty of 4s. 6d
2. After seven days and within one month, on payment of duty and a penalty of £10
3. A charter-party first executed abroad may be stamped within ten days after it has been received in the United Kingdom, or before it has been signed by any person in the United Kingdom.

   The charterers should be notified in writing when the ship is ready to receive cargo.

A charter-party only comes into operation when one man or firm owns a vessel and another man or firm charters her. When an owner or a regular line of steamers send a vessel of their own or a voyage, a charter-party, of course, is not required.

Commission.—The amount payable to a shipbroker when he is the medium through which the charterers and shipowners are introduced to each other. It is calculated as a percentage on the freight payable on the charter-party.

Commission is also a term denoting the amount payable to agents for transacting ship's business.

Address commission is commission payable at port of discharge.

Consignee.—The person or firm hom goods or cargo is consigned, that is, the one authorised receive them. Where agents are authorised to act for the own f a vessel in a foreign port, they are termed the "consignees of t hip "

Constructive Total Loss.—A vessel is nstructive total loss when she is so badly damaged that the cost epairing her would exceed her value when repaired. A survey the vessel should be held and an estimate of the cost of repairs ained Also, the master should get a certificate stating what wo be the value of the vessel if repaired. The report of surveyors, nate of cost of repair, and certificate, should be sent to the owners

Where a vessel becomes a constructive total los the owner is entitled to claim for a total loss supposing the vessel be insured. It must, however, be clearly proved that the vessel actually a constructive total loss, and that her condition is suc that he shipowner himself, if the vessel was uninsured, would n attempt to repair or refit her.

CUSTOM HOUSE REGULATIONS (BRITISH).

Entering Inwards.—The master of every vessel, wether laden or in ballast, must, **within 24 hours of arrival** at any port in the United Kingdom, make due report of such vessel to the Collector of Customs, and such report (except in cases specally provided for) must be made before breaking bulk. Penalty for ot reporting or for false report, £100.

Papers Required.—The papers required are register, manifet of cargo and stores, certificate of pratique,* and last ligh bill, also, if a grain-laden ship, the grain certificate.

Masters have also to state at the time of reporting whether hey have passed any dangers to navigation such as wreckage, dere ict vessels, or ice, and if so to specify particulars. Also to make a declaration that all letters (if any) carried by the ship have bee delivered to the Post Office.

Clearing Inwards.—When the inward cargo is discharged the Customs Examining Officer finally rummages the vessel and checks the stores remaining on board. He then calls on the master or person

* Obtained from the Customs officers at the landing station on entering the port.

in charge of the vessel for the B.B.* certificate, and on its production he issues the inward clearing bill or jerque note.

Entry Outwards.—No outward cargo must be shipped until the ship is entered outwards at the Customs. In entering outwards the jerque note mentioned above is supposed to be produced. The practice, however, varies at different ports, and in large ports the ship may, if necessary, be entered outwards previous to the discharge of the inward cargo, the Customs officer on board taking care that no outward cargo is shipped until complete separation between it and any inward cargo remaining in the vessel is assured.

Clearance Outwards.—The master must produce the following documents:—

The register.
The outward light bill, receipted.
The A.A. certificate if a foreign-going ship, the C C. if in the home trade.

He must also answer any questions asked by the Collector of Customs relating to the ship, cargo, or voyage, and make a declaration of the contents of cargo and stores.

The **clearance label** (or **cocket card**), with the **victualling bill**† attached, which form the clearance and authority for the departure of the ship, are then signed and given to the master.

Vessels leaving in ballast do not have to produce the outward light bill receipt, unless carrying passengers, as they are exempt. The inward light bill receipt must, however, be produced.

Bills of health are issued at the Customs Clearing House when required.

Dead Freight.—Freight paid on vacant stowage space, *i.e.*, when the amount of cargo shipped is less than the amount specified in the charter-party. The shipowner is entitled to freight on the shortage, just the same as if the ship carried it, and this is termed "Dead Freight."

Derelict.—The master of every British ship, who shall become aware of the existence on the high seas of any floating derelict

* See B.B.

† This is a document showing the bonded stores on board shipped solely for the vessel's use.

vessel, must notify the same to the Lloyd's agent at his next place of call on arrival. He must also give all such information as he may possess regarding the supposed locality or identity of such derelict vessel, the date and place where she was observed, etc.

The penalty for failing to make such a report is a sum not exceeding £5.

Disbursements.—Money disbursed by the master in financing the ship. **Vouchers** are receipts preserved by the master for production to the owners, along with his disbursement account.

The agents in a foreign port usually advance money to the master as cash for current expenditure, or there may be a balance of freight to draw upon. But if neither of those means are available and there are considerable expenses to be met, then the master may give the creditors a "bill" on the owners

Grain Certificate.—Before a British ship laden with a grain cargo at any port in the Mediterranean or Black Sea, and bound to ports outside the Straits of Gibraltar, or laden with grain cargo on the Coast of North America, leaves her final port of loading, or within 48 hours after leaving that port, the master shall deliver, or cause to be delivered to the British Consular officer, or if the port is in a British Possession, to the chief officer of Customs at that port, a notice stating:—

(*a*) The draught and freeboard after the loading of her cargo has been completed.

(*b*) 1. The kind of grain and the quantity thereof.
2. The mode in which the grain cargo has been stowed.
3. The precautions taken against shifting.

When arriving at a port in the United Kingdom the master shall also deliver a similar document to the proper officer of Customs This is done when the vessel is entered in at the Custom House.

Penalty for failing to make this report, or for making a false statement, a sum not exceeding £100 (Merchant Shipping Act 1894, Section 454).

Insurance Policy.—An agreement containing the conditions under which a ship is insured, and the perils she is thereby insured against. The policy is nullified if—

The ship deviates from her voyage.

If she be engaged in any illegal trade.

If she was unseaworthy at the time of insuring.

The underwriters are those who render themselves liable for the insurance by signing or underwriting their names at the foot of the policy There is usually a clause at the foot of a policy excluding claims which do not amount to 3 per cent. of the value insured.

It is very important where a vessel has put into port in distress to have a certificate of seaworthiness before leaving.

Warranties.—Where a ship in an insurance policy is warranted to sail on or before a date named. Other clauses in an insurance policy are also termed warranties ; for example—the ship and freight are warranted free from average under 3 per cent., unless general, or the ship be stranded.

Invoice.—A list of goods, cargo, or stores, with the original prices of each, and intermediate charges, such as freight, insurance, etc.

Jetsam.—Goods or cargo cast into the sea for the preservation of the ship and remainder of cargo, the ship being lost afterwards, notwithstanding the effort made to save her by relieving her cargo.

Jettison.—The act of throwing goods overboard for the safety of the ship. When such goods sink to the bottom and are buoyed by those throwing them over, the term "Ligan" is applied to them.

Flotsam is the term applied to goods which are left floating when a vessel is lost or wrecked.

Jerquing.—A Custom House term denoting the final examination of the accounts of the cargoes landed by vessels.

Jerque Note.—When a vessel has discharged the whole of her cargo she is finally rummaged by the Customs officer, who also overhauls and checks stores, etc. If all is in order he issues the inward clearing bill, or jerque note.

Lien.—A legal right over property, or goods, to hold it until the claim against the owner of it has been satisfied. The shipowner has a lien on the cargo for freight unless the charter-party states the reverse, and if the freight is not paid the owner or master of the ship may warehouse the goods, giving the wharfinger or warehouseman a written notice that they are to be retained until the lien is discharged.

At the expiration of ninety days (or at an earlier date if the

cargo is a perishable one) the goods may be sold by public auction, but notice of the sale must be duly given, by advertisement in the local newspapers. The expenses of warehousing must be borne by the owner of the goods The owner has no lien on the cargo for demurrage or dead freight unless stated in the charter-party.

Maritime Lien.—The lien which the master and crew have on a vessel for their wages. The master also has a lien for any necessary expenses he has incurred on behalf of the vessel.

Light Dues.—A charge levied upon vessels for providing and maintaining the lighthouses, vessels, beacons, buoys, etc., for the benefit of shipping and navigation.

A vessel entering for bunker fuel only—providing she has not broken bulk, or taken on board mails, cargo or passengers, or called to receive orders—is exempt from light dues.

Vessels in distress, vessels navigated wholly and *bona fide* in ballast, several classes of small vessels, His Majesty's ships, and ships belonging to foreign Governments, are also exempt. (*See* Second Schedule to Merchant Shipping Act, 1898.)

A receipt for light dues must be given to the person who pays it, and a ship may be detained at any port until this receipt is produced to the officer of Customs.

Lime Juice.—One ounce each man per day to be served out to the crew as soon as they have been at sea ten days.

Lloyd's Agent.—In all parts of the world the Corporation of Lloyd's have agents. One of their duties as agents is to render to masters of vessels any advice or assistance which they may require in case of shipwreck, or damage to vessel or cargo. It must be remembered that Lloyd's agents have no official authority whatever over the master, and that they are the servants of Lloyd's. The master of the ship is responsible for both ship and cargo, and need not employ Lloyd's agent or follow his advice unless at his own discretion.

In case of loss or damage from some peril insured against, the settlement of claims, if the ship is insured at Lloyd's, will be much facilitated if immediate notice is given to the nearest Lloyd's agent.

Manifest.—A document containing a description of a ship, and a list of her passengers (if any), cargo and stores.

Mortgage of Ship.—A deed by which a ship is mortgaged or pledged as security for money advanced. Only the owner can mortgage a vessel

Pilot.—Legally the master is responsible to some extent for the safe navigation of a ship when a pilot is on board, even if pilotage is compulsory. The master may depose him if he proves incapable, either from illness, drunkenness or any other cause.

The master is also responsible for seeing that the pilot's instructions or orders are duly carried out.

The master is bound, if requested, to declare his vessel's draught of water to the pilot. Penalty for refusal—a sum not exceeding double the pilotage rates.

Penalty for fraudulently altering the marks denoting the draft—a fine not exceeding £100.

If a master knowingly continues to employ an unqualified pilot after a qualified pilot has offered his services, he is liable to a fine of double the pilotage.

The same fine is payable if a master continues to navigate his own vessel in a compulsory district after a qualified pilot has offered his services ; that is, of course, if the master is not exempt from pilotage, owing to his having obtained a pilotage certificate.

An owner or master shall not be answerable to any person for damage or loss occasioned by the fault or incapacity of any qualified pilot acting within a compulsory pilotage district, providing there is no contributory fault on the part of the master or crew.

The pilot, however, is only liable up to the amount of his bond, that is, £100, and the fee then being earned.

Portage Bill.—A bill, showing the wages earned, and the amounts due to each member of the crew at the end of the voyage.

Primage.—A percentage beyond the freight paid by the charterer.

Promissory Note.—A note promising unconditionally to pay a certain fixed sum to a specified person at a determinable time.

Protest.—When the ship arrives at her port of destination, or if she is obliged from any accident to put into an intermediate port, the master should appear before a public notary, or the Consul if

in a foreign port, and cause an entry or note of protest to be made, and sign it himself.

The entering or noting a protest should be done as soon after arrival as possible. It should be done within 48 hours, but if delayed, a note giving the reason of the delay should be entered on the protest.

The protest may afterwards be extended. This must be done within six months of being noted. The extended protest should contain a full narrative of the facts which form the subject of the protest; the facts being taken from the log book, or supplied from the recollections of the master, mate, or trustworthy seaman.

In most foreign countries the noting and extending of a protest must be made within a specified time limit in order to make it effective.

Protests are of great importance in connection with claims that may arise under insurances, and also in the adjustment of averages or claims on damaged cargo.

Copies of protests should be sent home to the owners.

Receiver of Wreck.—An officer appointed by the Board of Trade. He is generally the chief officer of Customs at the nearest port. His duty is to receive any wreck or wreckage which may be brought to or washed up in his district. A list is issued by the Board of Trade, setting out the different districts and receivers.

Register or Certificate of Registry.—When a vessel is registered as a British ship, a certificate is issued to that effect, and it contains particulars as to her name, port of registry, tonnage, build, principal dimensions, and other points identifying the vessel; also particulars as to her origin and name, and description of owner or owners.

The master of a vessel must see that his name is endorsed on the Register. This must be done in ordinary circumstances by the chief officer of Customs at the Custom House at a home port, or by the British Consul at a foreign port.

The certificate must only be used for the navigation of the vessel; that is, for production at the Custom House when entering or leaving port, and in other cases where it may be necessary.

Respondentia is a term used to denote the fact of money

being raised on the cargo as security. It differs from bottomry in the fact that the cargo is pledged as security, and that, even though the ship might be a total loss, if enough cargo was saved, the bond would have to be repaid.

Salvage.—An allowance or compensation paid to those who, by their efforts, have saved a vessel or goods from being lost.

Survey—Of Hatches.—The hatches should be surveyed before opening, and should be opened in the presence of the surveyor. A certificate should be obtained from him certifying to this fact; also when the ship is full of cargo the certificate should state that on lifting the hatches the vessel was found to be quite full. This may be valuable in case of a claim for short delivery of cargo

Of Cargo.—Damaged cargo should be surveyed before being disturbed so that the surveyor or surveyors may determine whether it has been properly stowed and dunnaged, etc. If the damage arises from insufficient dunnage or bad stowage the ship is liable for the amount of damage. Particulars as to the amount and extent of damage should be certified before the cargo leaves the vessel.

Of Vessels.—If a vessel receives material damage through stress of weather, stranding, or other causes, a survey should be held. The survey certificate should state fully the particulars of damage, how caused, and recommendations as to what must be done.

When repairs are completed a second survey should be held, and a certificate of seaworthiness obtained before proceeding to sea.

For such surveys, wherever there are competent surveyors to the Lloyd's Register, it is desirable that they be called in with the approval of Lloyd's agents, and the co-operation and approval, so far as possible, of any surveyor called in on behalf of underwriters or special officer appointed by a Salvage Association on behalf of underwriters should be obtained.

Surveyors.—At some ports there are licensed surveyors who are specially employed on these duties. For surveying cargo, at least one shipmaster or other person of nautical experience should be employed. For survey of ship, two shipmasters or, in their absence, two other qualified persons.

All surveyors must be disinterested parties.

The master should always be present, and all parties whose interests are concerned should be notified when a survey is to be held.

If damaged cargo is surveyed for the purpose of assessing the amount of damage, two produce merchants acquainted with the nature of the cargo (disinterested) should be employed.

CHAPTER XXI.

MISCELLANEOUS.

We have included in this chapter various drawings and subject matter which might have been more appropriately given in other parts of the book.

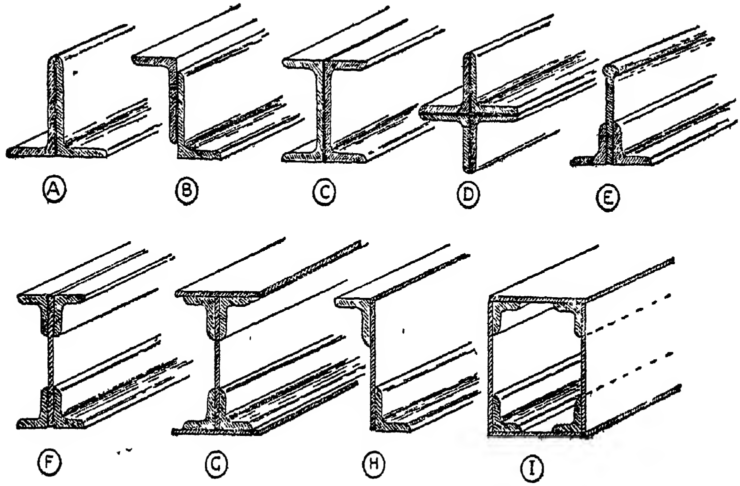


Fig 1.—Some Built Section

Some Built Sections.—Fig. 1.

A—Two angles back to back, heels together.

B—Two angles back to back, heel and toe.

C—Two channel sections, back to back.

D—Four angles, heels together.

E—Bulb plate stiffened with two angles.

F—Girder web stiffened on both edges with angles.

G—Girder same as *F* but further stiffened with a rider plate and a foundation plate.

H—Girder web stiffened top and bottom edge by single angles.

I—A box girder formed by four plates connected at the inside corners by angles.

See also page 448.

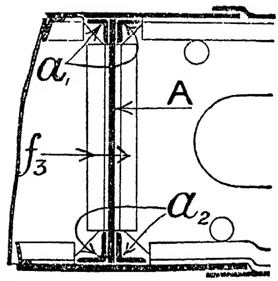


Fig 2.—Cellular Double Bottom.

Cellular Double Bottom.—Fig. 2 showing how the centre girder is connected to the floors and to the inner and outer bottom.

A—A continuous fore and aft centre plate.

a_1—Continuous fore and aft angles connecting centre plate to inner bottom.

a_2—Continuous fore and aft angles connecting centre plate to the flat plate keel.

f_3—Short vertical angles connecting the floor plate to the centre plate.

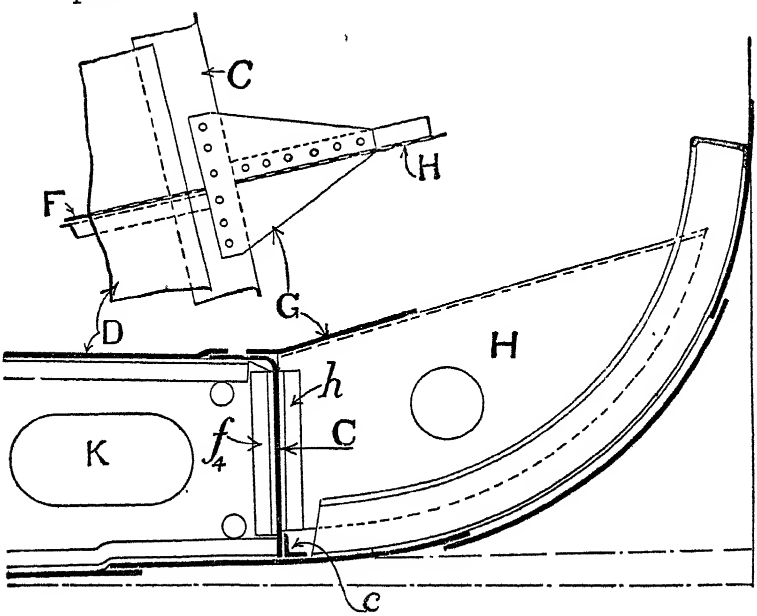


Fig 3.—Cellular Double Bottom

Fig. 3, showing the tank side arrangement of a C.D.B.

f_4—A vertical angle connecting the floor plate to the margin plate *C*.

h—A vertical angle connecting the tank side bracket *H* to the margin plate *C*.

c—A continuous fore and aft angle connecting the lower edge of the margin plate to the shell plating.

K—A hole in the floor to reduce the weight of material and to provide access to the cellular spaces.

The upper figure shows in plan how the connection of the tank side bracket to the margin plate may be strengthened by means of a half-diamond plate.

C—The flange of the margin plate.

G—The half-diamond riveted to the flange and to the reverse frame *H* on the upper edge of the bracket.

F—The stiffening angle along the top edge of the floor.

D—The inner bottom plating.

Figures 2 and 3 are enlargements from the drawing on page 440.

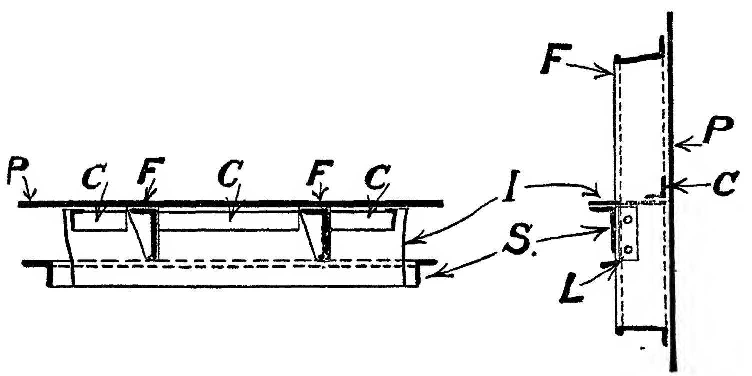


Fig 4—Stringer.

Stringer.—Figure 4 shows a plan and a sectional elevation of part of a stringer.

S—A continuous stringer angle.

I—Intercostal plate slotted in way of frames *F* and *F*.

C—Chock angles fitted between the frames to connect the stringer plate to the shell plating *P*.

L—A short lug piece to connect the continuous stringer angle *S* to the inner edge of the bulb frame.

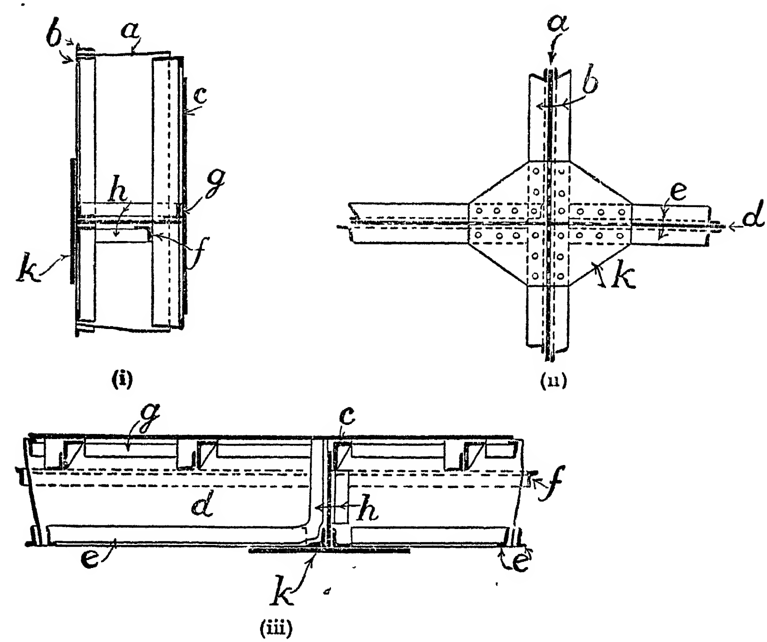


Fig 5.—Web Frame and Stringer.

Web Frame (see also page 443).—Figure 5 (i), (ii), (iii) are three views of a web frame at its juncture with a stringer.

(i) This is a view from aft.

c—The frame angle riveted to shell plating.

a—The web stiffened on its inner edge by angles *b*.

k—A diamond plate as shown in (ii).

h—Short angles connecting the web to the stringer plate.

g—Short chock angle fitted between the frames to connect stringer to shell plating.

(ii) A side view.

k—Diamond plate connecting the continuous vertical angles *b* on the edge of the web *a* and the angles *e* on the edge of the stringer plate *d*.

(iii) A plan view of the stringer.

c—The frame angle.

g—Chock angle.

d—Stringer plate notched in way of frames to fit against shell plating.

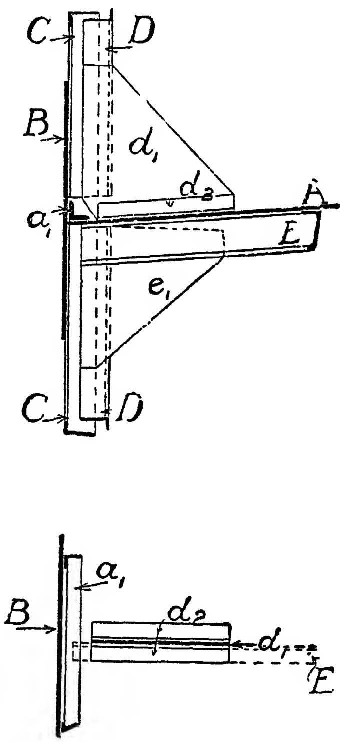
h—Angles connecting web to stringer plate.

f—Angle on under side of stringer plate connecting it to the frames.

e—Stiffening angles on inner edge of stringer.

k—The diamond plate.

Watertight Flat (see also page 452). Fig. 6—



(i) (ii)

Fig. 6.—Watertight Flat.

(i) The frame and reverse frame are cut to allow the deck flat plating to fit against the shell plating *B*, to which it is connected by the continuous fore and aft angle *a*.

d_1—Bracket riveted to the frame.

d_2—Angle connecting bracket to deck plating.

E—Beam, and e_1, the beam knee.

(ii) A view in plan, the index lettering being the same as above.

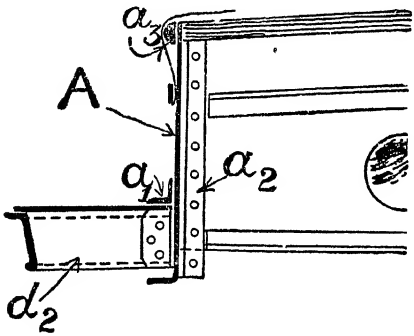


Fig. 7.—Hatch Coaming.

Hatch Coaming (see also page 459). Fig. 7—

(i) A—Coaming plating.

a_1—Angle connecting coaming to deck plating.

d_2—Deck beam.

a_2—Vertical angles inside coaming to form a slot to receive the end of the portable athwartship beam, they also stiffen the plating.

a_3—A half round section on upper edge of coaming.

It will be noticed that the end of the half beams are connected to the lower edge of the coaming in conformity with modern practice. Formerly, however, the ends of half beams were connected to an independent fore and aft vertical plate called a "carling" which extended the length of the hatchway. A plate similar to a hatch carling may be fitted to secure the inner end of a half beam when cut in the way of a mast coaming. These fore and aft vertical plates are then called the mast "partners."

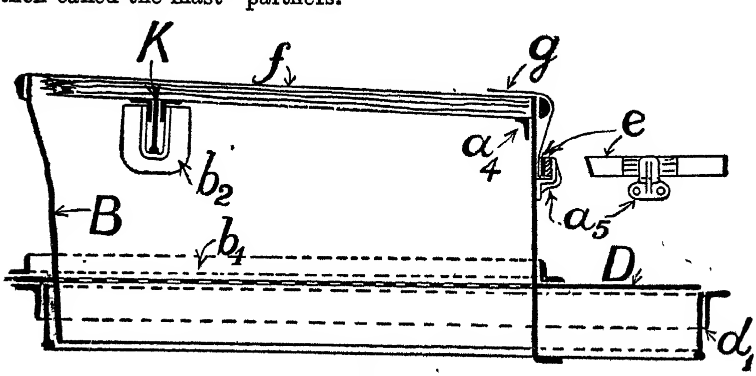


Fig. 8.

(ii) This is a hatch end.

B—The athwartship coaming.

b_2—Carrier for the end of the portable fore and aft beam K to rest in. Length of bearing 3 inches.

b_1—Angle connecting coaming to deck plating.

f—Wood hatch covers at least $2\frac{1}{2}$ inches thick.

a_4—Ledge $2\frac{1}{2}$ inches broad for hatch covers to rest on.

g—Tarpaulin.

a_5—Cleats 2 feet apart and $2\frac{1}{2}$ inches wide.

e—Flat iron bar to grip the tarpaulin when wedged up tight at the cleats.

Deep Tank Top.—Fig. 9 illustrates a method of making the portable top of a tank watertight or oiltight. Note the washer of soft material, rope or rubber usually, between the top edge of the

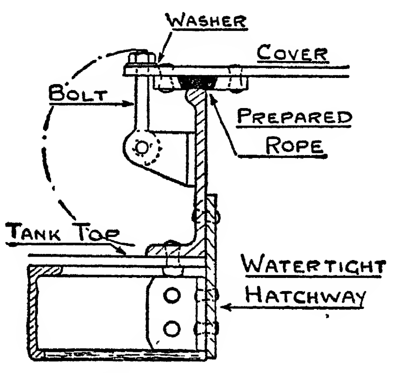


Fig. 9.—Deep Tank Top.

coaming and the under side of the steel cover, and how close contact is secured by means of numerous bolts and nuts round the coaming. Wing nuts are usually fitted to the deck hatches of oil tankers. Note also the hinged bolts which fit into slots in the edge of the cover.

Fig. 10.—A hatch coaming as sometimes fitted in small vessels with large cargo hatch openings.

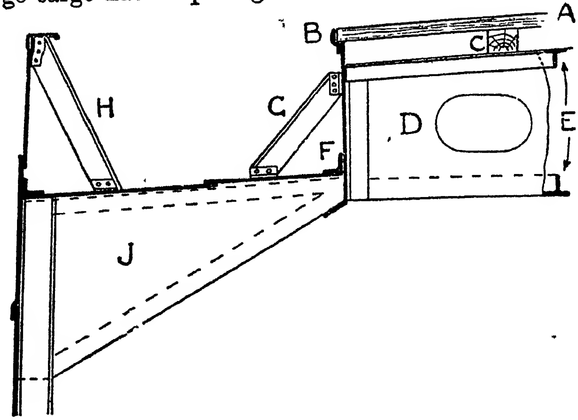


Fig 10.—Hatch Coaming.

A—Wooden hatch cover resting on ledge *B* and on wood fore-and-after *C*, which in turn rests on the portable hatch beam *D*.
E—Stiffening angles on lower and upper edge of hatch beam.
F—Angle connecting coaming to deck plating.
G—Stanchion connected to coaming and to deck plating by lug pieces to give support to coaming.
H—Bulwark stanchion.
J—Large bracket to contribute compensation for loss of strength due to cutting beams in way of wide hatchway.

Strum Box.—Fig. 11 shows a strum box enclosing a bilge suction

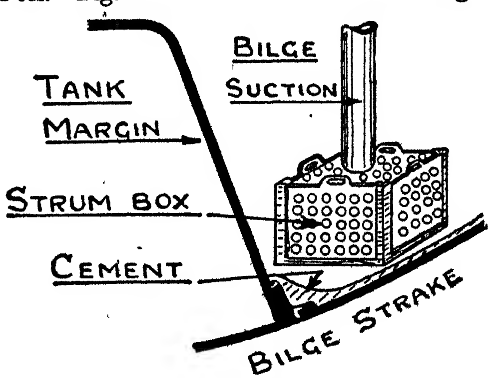


Fig 11 —Strum Box.

to protect the end of the pipe. At least one side of the box is removable for cleaning-out purposes; this drawing shows the four sides as a sliding fit into the framework of the box. Suction ends in hold spaces are enclosed in strum boxes having perforations not more than three-eighths inch in diameter, whose combined area is not less than twice that of the suction pipe.

It is very important to make sure that the strum boxes are cleaned out and the suction ends clear before commencing to load cargo.

Downton Pump (Fig. 12).—This hand pump is operated by means of a flywheel and a handle which turns a crank inside the housing. The crank lifts and lowers the piston, or plunger, and an inspection of the sectional drawing will indicate how the suction and delivery valves open and close turn about as the piston goes up and down.

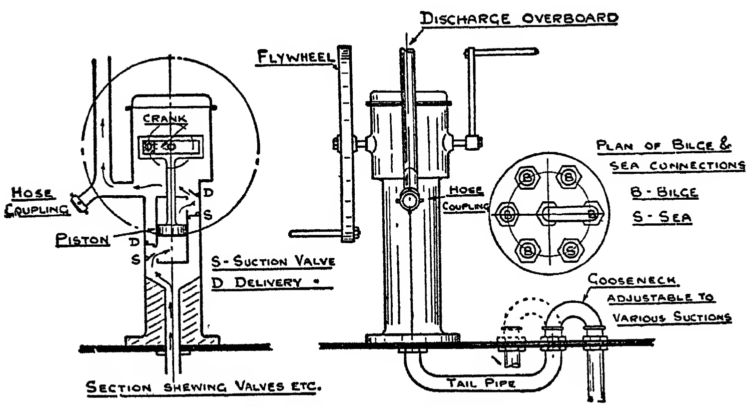


Fig. 12.—Downton Pump.

The tail pipe is fitted with a gooseneck to fit on to various bilge suction pipes, or to a sea connection.

This pump may be utilised to pump out any compartment fitted with connections, and the delivery may be directed on deck as indicated by the hose coupling, or discharged overboard.

Freeing Ports.—The openings in the bulwarks to clear the decks of water when heavy seas are shipped may be left as openings with safety bars across them spaced not more than 9 inches apart, or they may be fitted with a hinged door which opens and closes automatically.

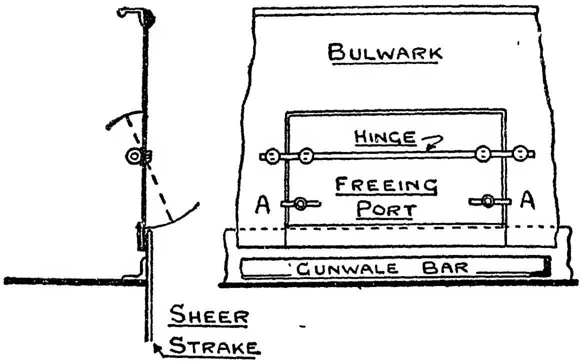


Fig 13.—A Freeing Port.

Fig. 13 illustrates one type of closing port. It is hinged about one-third from the top edge. The end elevation shows that when the vessel rolls the water runs to leeward, pushes outwards against the port, which it opens, and flows overboard.

The area of freeing ports depends upon the area of the bulwarks according to the following scale :—

Well deck in feet		25 ;	area of openings in sq. ft.			9
,,	,,	45 ;	,,	,,	,,	11
,,	,,	65 ;	,,	,,	,,	13

In well decks above 65 feet in length the area of freeing port is 1 square foot for every 5 feet of bulwark, thus, 80 feet bulwark would require 16 square feet of openings.

Ventilator.—Fig. 14 illustrates a common type of ventilator. It is trimmed as required by turning the cowl *A* on its coaming *B*, which is secured to the deck by a watertight collar *C*. An inner tube of smaller diameter than the coaming leads down to the lower hold. The current of air passes down the inner tube of the ventilator to the lower hold, but some of the air is diverted into the 'tween deck through the annular space between the tube and the coaming.

Two or more ventilators are fitted to each hold in tramp steamers, one, the lee one usually, being trimmed mouth to wind and the other one back to wind, thus forming a downtake and an uptake to create a continuous current of air throughout the hold. Some cargoes give off gases lighter than air, coal for example, and in such cases surface

ventilation is needed, and the ventilators should be turned backs to the wind. Coal is less likely to ignite if starved of air. See page 392.

When bad weather approaches, especially at night, and the vessel is likely to ship heavy water, it may be necessary to turn all ventilators back to wind and perhaps to put a canvas cover over the

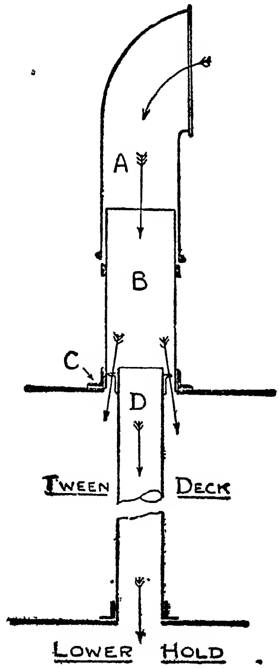


Fig. 14.—Ventilator.

cowl if they are not high enough to prevent spray and sea water getting into them. During heavy weather at night time it is desirable to inspect occasionally the ventilators and hatch covers to ensure that everything on deck, fixed or movable, fittings or cargo, is secure, and that deck openings are properly covered and watertight.

FROZEN MEAT.

The following photographs illustrate a method of slinging carcases of frozen meat. The carcases are stowed in the canvas sling head and tail alternately. About 80 carcases can be lifted in one sling without risk of damage and with a minimum opening of the

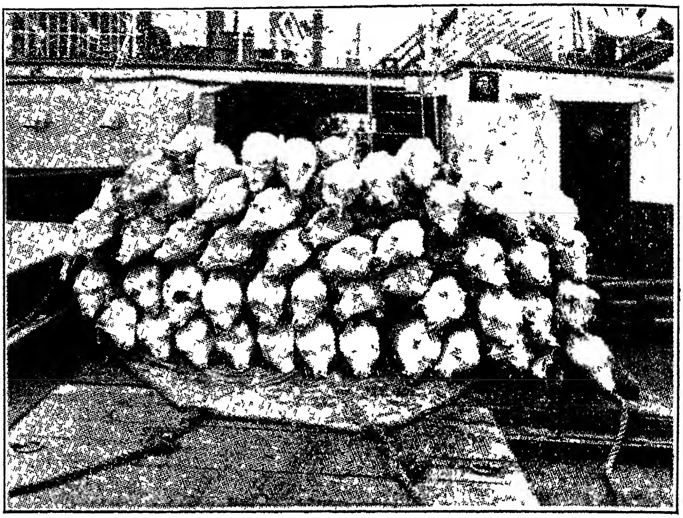


Fig 15.—The set made up in tiers head and tail alternately.

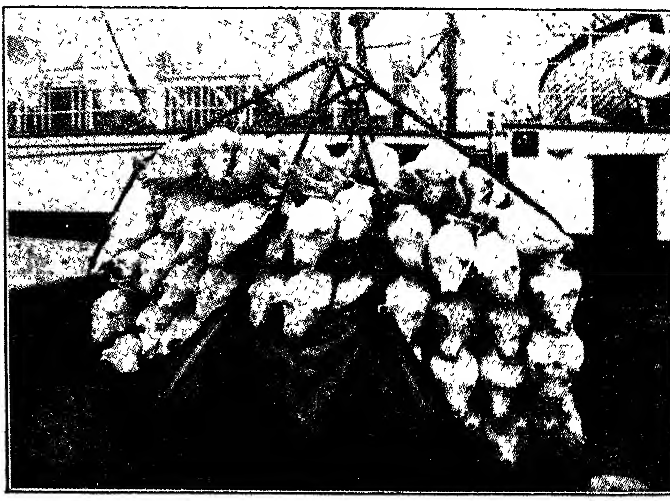


Fig. 16.—View of sling when being lifted.

hatchways. The carcases are stowed in the hold fore and aft, bottom tier on their backs and belly to belly afterwards. The hold temperature during the passage is kept as near as possible to 15° Fahr. See also page 410.

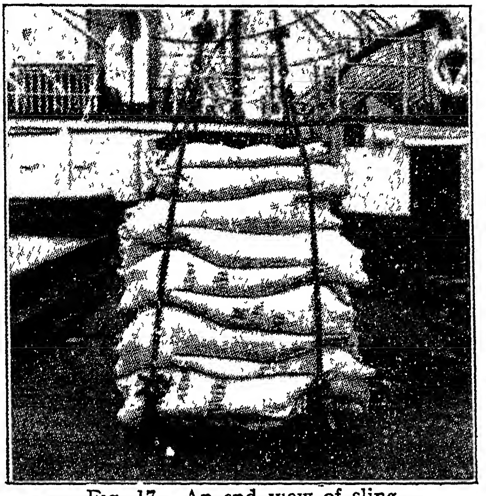


Fig 17.—An end view of sling.

RELIEVING TACKLE.

When there is considerable play on the rudder due to worn pintles and the back kick on the steering gear is severe, especially during heavy weather, it is desirable to fit an arrangement to reduce the wear due to constant jolting. The kick of the rudder causes a sudden jerk on the steering gear, and in small vessels steered by hand gear the back-lash may be heavy enough to throw an unsuspecting helmsman over the wheel if he held on to it.

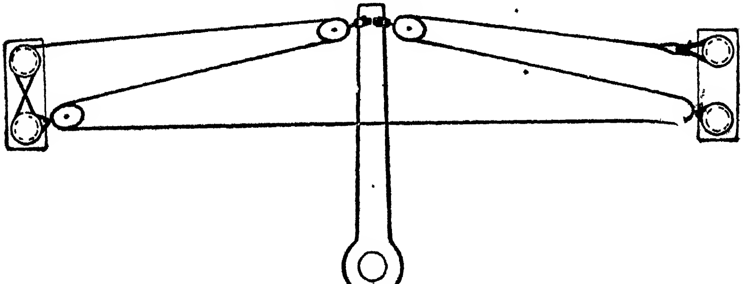


Fig. 18.

Fig. 18 shows a simple relieving tackle for small vessels, but in large vessels this is quite inadequate, and many are fitted with a friction brake. one of the simplest and most effective being the "Dunstos" Rudder Brake as illustrated.

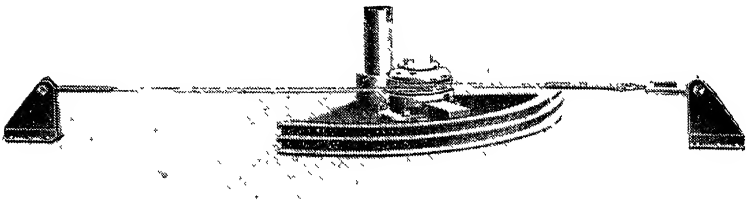


Fig 19

Fig. 19 gives a general view of the arrangement. Two brackets are fitted on deck, one on each side of the quadrant, and a free wheel rotating on a vertical axis, the foundation of which is bolted to the middle of the quadrant near to its circumference. The end of a wire is shackled to one bracket, a turn of the wire is taken round the pulley, and the other end of the wire is set up tight to the other bracket by means of a tightening screw.

Frictional resistance to back-kick is obtained as follows (see Figs. 19 and 20) :—

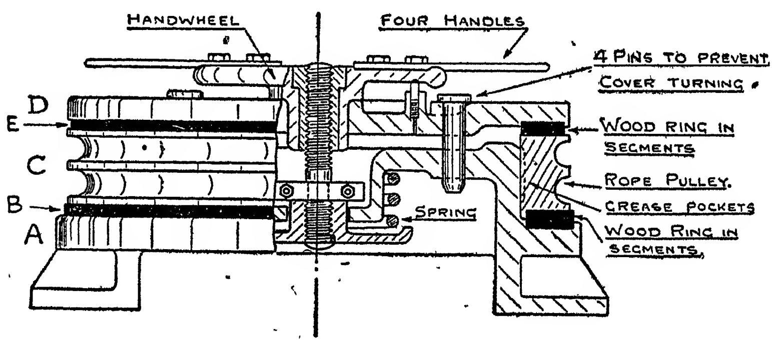


Fig. 20.

A base plate *A* with a central axis having a recess all round is securely bolted to the quadrant, the circular recess in base is fitted with hardwood in segments *B*.

A double grooved sheave *C* is fitted, free to revolve on the axis of the base plate, the bottom of the sheave rests upon the wood *B*,

and a loose plate or cover *D* rests on top of the sheave, with wood ring *E* between them. This cover is prevented from turning by pins.

A hand wheel engages with a screw operating a spring; by turning this wheel the grooved pulley is compressed against the wood and retarded or released at will

As the rudder moves, the sheave revolves, and by simply turning the hand wheel any desired resistance can be applied, this depending on the state of the weather; you simply screw down little by little, till the gear stops kicking, and as the weather moderates ease up to suit. In fine weather the sheave runs freewheel, or the wire may be taken off. In the event of a steering chain carrying away, the quadrant may be held in position by screwing the brake hard down until the hand gear is connected or the chain repaired or replaced.

ROPE.

Rope is made of manilla, sisal, hemp or coir fibres twisted into yarns, the yarns into strands, and three strands, sometimes four, are laid up together to form a rope.

Manilla is glossy, smooth, and pliable and good.

Sisal is stiff, harsh, short fibre and not so good. A proportion of both manilla and sisal is frequently worked into one rope.

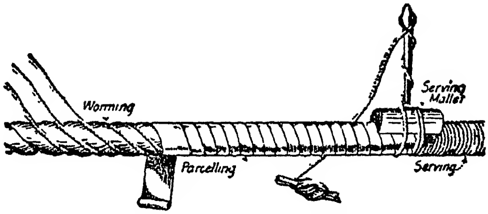
Hemp is the best fibre, of great strength and durability, flexible when wet and wears to the last rope yarn.

Boltrope is tarred hemp used for sewing round sails to strengthen the head, foot and leech, also for lanyard rigging.

Coir is made from cocoanut husk fibre; it is reddish in colour, light in weight, about half the strength of manilla, stretches before parting, and is often used for mooring alongside a wharf where a ground swell is making a ship range heavily. Coir does not absorb water, is buoyant, and therefore handy for harbour work when running hauling lines by boat across a dock.

Hawsers.—Any rope over 5 inches may be called a warp or hawser.

Small Stuff.—Marline is two yarns of tarred hemp spun together; housline is three yarns, and both are used for worming and serving ropes and for seizings. Spunyarn is softer, made of two or three coarse yarns and is used for serving and general work on board ship.



Worming Parcelling and Serving

Fig 21.

Protection of Rope.—Some ropes have to be protected from chafing. The rope is first wormed by filling in the lay with small stuff to make it more nearly round, it is then parcelled with strips of tarred canvas about 2 inches broad and finally it is served, that is, spunyarn is wound tightly round the parcelling with a serving mallet or board, all according to the rhyme, " Worm and parcel with the lay, turn and serve the other way."

Preservation of Rope.—Taut ropes when dry should be slacked off when wet. They should not be coiled away when wet or damp, but coiled down loosely on gratings or flaked over a boom to ensure them being well aired and dried before storing them away. Rope lockers should have sparred shelving and all ropes should be brought on deck occasionally to be sunned and aired, as particles of salt remaining in the rope draw dampness, which produces dry rot. Hauling lines stored on deck should be covered over, especially those aft, to protect them from grit and cinders from the funnel.

Ratline is small rope made of tarred hemp, and its size is referred to as 15, 18 or 21 thread ratline as the case may be. Its original purpose was to form a rope ladder across the shrouds by which to climb the rigging, but wooden battens or iron rods are now more commonly used. Many steamships have an iron ladder built on the mast, and big ships may have the ladder leading to the crow's nest inside the mast.

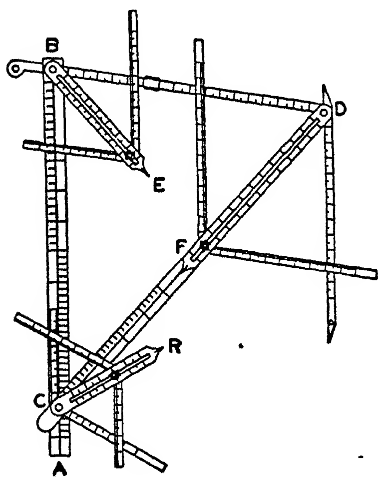
To rattle down you begin at the bottom and rattle up, but first the shrouds are set up equally taught, widely spaced battens are seized across them to keep the shrouds rigid, and the ratline, direct from the coil, is clove-hitched loosely round each shroud from left to right except the forward and after shrouds, to which it is seized.

The eyesplice on the end of the ratline is seized to the right

hand shroud, then tightened up from right to left, and finally the other end is seized to the left hand shroud.

The next higher ratline is done in the same way, and they are spaced 15 inches apart.

The **Lansley Stress Finder** comprises a set of movable metal scale bars which can be set to solve the various parallelograms of forces in connection with derrick work without calculation.



A B represents the mast which is adjustable up or down to suit the height of span above the gooseneck.

B D the span or topping lift.

C D the derrick.

B E shows the stress on the block at *B*.

D F gives the thrust on the derrick.

C R is the stress on the heel block at *C*.

The other arms show the various component stresses involved.

The makers are Messrs. Kelvin, Bottomley and Baird, Glasgow.

PAINT.

(See also page 480.)

Preparation of Surfaces.—All loose paint, rust, dirt and grease should be removed from ironwork and the metal thoroughly dried before applying the paint. The preparation of the material is of great importance to enable the paint to secure a firm grip on the material by penetrating into the surface pores. Paint won't cling to a dirty face.

Paint is usually sent on board ready mixed and only requires stirring, and perhaps thinning with linseed oil and turpentine before application. Red lead, however, is generally in powder, and if mixed solely with oil the heavy pigment settles and forms a hard, solid mass on the bottom of the container. This tendency is reduced by first mixing the powder with water to form a stiff paste, then,

by adding linseed oil gradually the water is displaced which oozes to the surface and can be poured off. This seems to prevent the particles from uniting so firmly as to form a solid mass.

Covering Properties.—This varies considerably according to the consistency of the paint, the roughness of the surface, and the temperature. A fair average is 50 square yards per gallon for good paint.

Bituminous Compositions.—This composition is largely composed of pitch, and other ingredients as rosin, cement, slaked lime and petroleum. It is made up as a solution, an enamel and a cement. Bituminous paint solutions are applied with a brush; enamel is applied hot and is poured or spread over the surface; bituminous cement is also applied hot on horizontal surfaces. The cement is used as a protective coating in ballast tanks, chain lockers, bunkers, engine and boiler foundations, and as a damp proof coating where required.

Antifouling compositions referred to on page 481 are poisons manufactured usually from copper, mercury, arsenic or other mineral poisons, the object of the composition being to dissolve slowly on contact with the sea water so as to form an antiseptic film or surface to destroy the marine growth before it has time to develop.

Marine Growths.—The innumerable animalculae which live in the sea are known as plankton, and this microscopic animal and plant life is usually more abundant in coastal waters than in mid-ocean. The plant life forms weed or "grass" fouling on the submerged shell of the ship, but as this green growth requires light its location is confined to a strip along the waterline.

The Barnacle which attaches itself to the skin surface starts off as a microscopic egg floating about in the sea On reaching the larval stage it swims freely, develops eyes, and appendages bearing suckers furnished with glands which secrete an adhesive cement thus enabling it to attach itself to hard underwater surfaces. The barnacle having fixed itself to the plating of a ship grows gradually into adult form and cements its back to the plating and feeds on any microscopic organism that comes within range of its legs, which are fringed with fine hairs to scoop into its mouth the organisms.

The Toredo Worm bores its way into timber. It is a mollusc floating in the sea which, on finding a suitable medium, enters the

wood by cutting a small hole the size of a pinhead. The mollusc then bores its way into the wood, develops in length to a few inches, and lines its burrow with a shelly substance which it secretes. The wood in time soon becomes riddled with holes and crumbles away.

DRYDOCKING.

(See also page 339.)

A Graving Dock is one with a cofferdam gate. The gate is opened, the ship floated in, the gate is then closed, the water pumped out, and the ship is left resting on keel blocks and steadied upright by side shores and bilge shores.

A Floating Dock has no ends, but has a double bottom and high side tanks. The tanks are flooded with water until the bottom of the structure sinks below the level of the vessel's keel. The vessel is floated in, and steadied into position, the tanks are then pumped out, and the dock rises under the vessel and lifts her up.

A Slipway is a cradle on an inclined railway track extending into the water. The cradle is run down the trackway under the vessel, which she approaches bow on, rides on the cradle, and is hauled up the slip by means of winches and wire purchases.

In Dry Dock.—Examine all underwater valves, sea cocks, injection and ejection pipes, and particularly rudder pintles, gudgeons and bearings for clearances and renewals. Take a note of any indented plates if they are not to be renewed, remembering that they are indicated by letters *A*, *B*, *C*, etc., from the keel upwards and numbered 1, 2, 3, etc., from aft forward. Propeller nut and boss should be examined for corrosion, and zinc plates, if any, renewed. Look for evidence of leakage at riveted joints in way of peak tanks, and bulkheads due to panting, and encircle the rivets with a chalk mark as they will either have to be caulked or renewed.

When any rivets have been knocked out for the purpose of draining water ballast tanks it will obviously be necessary to make sure that the holes have been reriveted.

When repairs and painting have been completed notify the chief engineer when water is to be run into the dock, so that he may ensure that all underwater openings will be closed.

A Sailing Ship (Fig. 23).—A head-on view showing the square sails on the foremast. The names, given in their order upwards, are :—Foresail, lower topsail, upper topsail, topgallant sail, royal. Note the buntlines for hauling the foot of the sail up to the yard. They are seen girting across the belly of each sail.

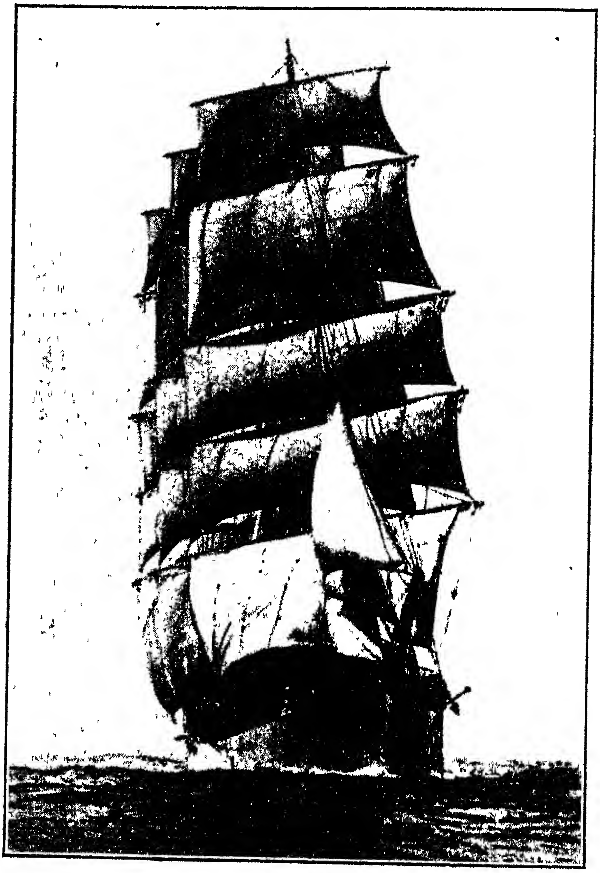


Fig. 23.

Fig. 24.—A broadside view. The square sails are named the same on each mast as on the foremast, with the exception of the lower sail on the mizzen, which is called the crojack. The mainsail and crojack in the photograph are furled. The fore, main and mizzen

royals have just been unfurled, to be ready for setting by hauling out their clews by means of their sheets to the yardarms of their respective topgallant yards, and then hoisting the yards to the royal masthead by the halliards.

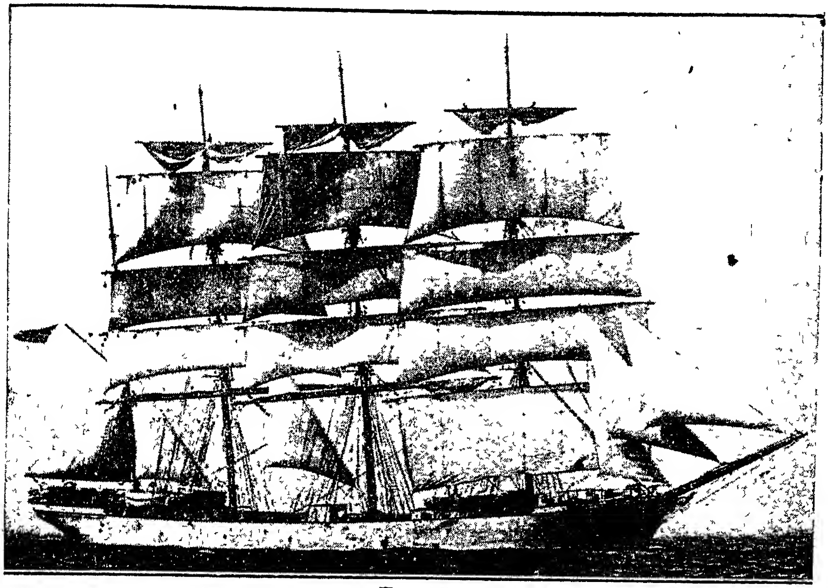


Fig. 24.

Barque *Carradale* launched 1889, scrapped 1925.

The fore and aft sails that are set, starting aft, are named :— Spanker, jigger staysail, mizzen topmast staysail, and on the bowsprit there are the fore topmast staysail, inner jib and outer jib.

Spare parts for rod and chain steering gear; by agreements between the Ministry of Shipping and the Shipping Federation.

Ships under 12 knots:—

1 complete spring buffer and 1 spare spring. 2 tested chains equal to the longest length in the gear or, alternatively, 1 spare set of all the lengths on one side.

2 bottle screws; 2 sheave pins; 4 shackles; 4 connecting links; 4 rod pins.

Ships over 12 knots and all Home Trade ships and Coasting vessels.

1 tested chain equal to the longest length in the gear.

1 spring buffer; 1 bottle screw.

4 shackles; 4 connecting links· 4 rod pins; 2 sheave pins.

CHAPTER XXII.

INTERNATIONAL CODE OF SIGNALS.

CHAPTER XXII.

THE INTERNATIONAL CODE OF SIGNALS.

EXTRACT FROM THE REGULATIONS.

THERE are seven editions of the International Code of Signals translated into seven languages, English, French, German, Italian, Japanese, Spanish, Norwegian, and from January 1, 1934, the new Code will supersede the former Code. The book consists of two volumes, Volume I. is devoted to Visual Signals by Flags, Morse and Semaphore; Volume II. to Radio Signalling.

Although the majority of radio signals to and from ships are, and doubtless will continue to be, transmitted in plain language, and between foreigners often in the English language, it was considered that an International Code for use by radio was needed to make full use of the exceptional means of communication with which radio provides them, and because there are in many parts of the world those who are not well conversant with any other language than their own. A further advantage of the new Code lies in the fact that nautical and technical expressions have been adjusted in the seven editorial languages so that the use of the Code should facilitate the exchange of correct and concise information between people not speaking the same language.

The Code is primarily intended for use by ships and aircraft; and, *via* shore radio stations, between ships or aircraft and authorities ashore, such as harbour authorities, quarantine authorities, agents, etc.

The one, two, three and four-letter flag hoists are arranged in alphabetical order, as also are the chief words of their corresponding phrases and sentences, so that coding and decoding can usually be made at one opening of the book. The four-flag signal letters of ships are given in a separate book entitled *The Mercantile Navy List* and also in another book called *Signal Letters of British Ships*. The top flag of the hoist indicates the nationality of the vessel; for example, the top letter of the names of British ships is flag "*G*" or flag "*M*."

THE CODE FLAGS.

The set of Code flags consists of 26 alphabetical flags (one for each letter of the alphabet), 10 numeral pendants (one for each unit 1, 2, 3, 4, 5, 6, 7, 8, 9, 0), 3 substitutes and the Code pendant—40 flags in all.

Five new flags have been introduced, *C*, *D*, *E*, *F* and *G*, to replace those letters of the former Code which were represented by pendants; those pendants, without alteration, now indicate respectively the numerals 1, 2, 3, 4 and 5 of the new Code with the addition of five new pendants to make up 6, 7, 8, 9 and 0, the decimal point being indicated by the Code pendant. A pendant now represents a numeral only and is referred to as No. 1 numeral, No. 2 numeral, etc., and a flag represents a letter of the alphabet and is referred to as letter "*A*" or letter "*B*," etc.

Single-letter signals, one for each flag, are either very urgent or of very common use. A second series of single-letter hoists are towing signals. See page 636.

Two-letter hoists are mostly distress, urgent and important signals with the addition of a few general signals of common use. See examples, pages 636 and 637.

Three-letter signals are general in character and are used for words, phrases and sentences. See examples, page 637.

Four-letter hoists commencing with the letter "*A*" are geographical signals, and four-letter hoists commencing with letter *G* are the signal letters of British ships.

USE OF THE SUBSTITUTES.

The substitutes are intended to indicate a repeat of the same flag, or pendant, in a hoist, so that double or even treble letters or figures may be conveyed in the same hoist by one set of flags only.

GEOGRAPHICAL HOISTS

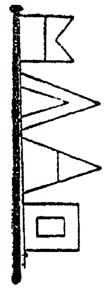
Example.—Letters *A A A S* mean Aberdeen, Scotland, and would be hoisted.—

A

1st sub

2nd sub

S



1st substitute means repeat the top letter of the hoist, namely *A*, and 2nd substitute means repeat the second letter of the hoist, which, in this case, is also *A*, thus making the hoist *A A A S*.

Note.—It might be a useful lesson in flag identification if the student were to put in the colourings of the respective flags in the several illustrations given here.

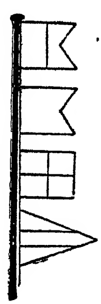
Example.—Letters *A B U U* mean Blacksod Bay, Ireland, and would be hoisted.

A

B

U

3rd sub



3rd substitute means repeat the third letter of the hoist, which in this case is *U*, thus making the signal *A B U U*.

These are two examples of geographical signals intimating the names of places and all such signals are four-flag hoists beginning with flag *A*. The hoists and the names of the places are arranged in the Code book in strictly alphabetical order, in parallel columns, the name of the place and its hoist being alongside of each other, so that code and decode are made simultaneously at the same opening of the book.

NUMERAL HOISTS

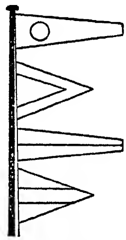
Example.—Numeral signals are made without reference to the Code book. If it were required to signal the number 2266, then the hoist would appear—

No. 2 pend't

1st sub

No. 6 pend't

3rd sub



1st substitute means repeat the top numeral of the hoist, which is 2, and 3rd substitute means repeat the third numeral of the hoist, which is 6, thus making the signal 2266.

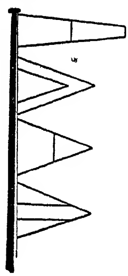
Example.—Signal the number 5555.

No. 5 pend't

1st sub

2nd sub

3rd sub



1st substitute means repeat the top numeral.

2nd substitute means repeat the second numeral just as if No. 5 pendant had been hoisted instead of 1st substitute.

3rd substitute means repeat the third numeral from the top, just as if No. 5 pendant had been hoisted instead of 2nd substitute, thus making the signal 5555.

This is the extreme limit to which the use of the substitutes can go, and no substitute can be used more than once in the same group.

Example.—To signal the fishing vessel registration number *Y H* 344, we would hoist—

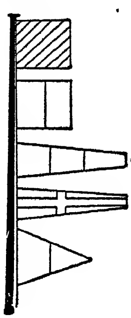
Y

H

3

4

2nd sub



The 2nd substitute, in this sense, means repeat the second numeral, viz., No. 4 pendant, because the 2nd substitute is in the numeral part of the hoist, thus completing the signal *YarmoutH* 344.

SINGLE-LETTER HOISTS.

Single-letter hoists relate to important phrases which are in common use.

Single-letter Signals.

Only those marked with an asterisk should be used by flashing

A I am undergoing a speed trial.

B I am taking in or discharging explosives.

C Yes (affirmative).

D Keep clear of me—I am manoeuvring with difficulty.

E I am directing my course to starboard.

**F* I am disabled. Communicate with me.

G I require a pilot.

H I have a pilot on board.

I I am directing my course to port.

J I am going to send a message by semaphore.

**K* You should stop your vessel instantly.

**L* You should stop. I have something important to communicate.

M I have a doctor on board.

N No (negative).

**O* Man overboard.

**P* In harbour (Blue Peter)—All persons are to repair on board as the vessel is about to proceed to sea. (*Note*: To be hoisted at the foremast head.)

At Sea—Your lights are out, or burning badly.

Q My vessel is healthy and I request free pratique.

**R* The way is off my ship; you may feel your way past me.

S My engines are going full speed astern.

T Do not pass ahead of me.

**U* You are standing into danger.

**V* I require assistance.

**W* I require medical assistance.

X Stop carrying out your intentions and watch for my signals.

Y I am carrying mails.

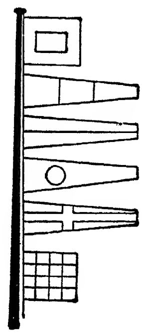
**Z* To be used to address or call shore stations.

Letters *P*, *T* and *X* have also special significance when signalling latitudes, longitudes, times, courses and bearings in degrees, all of which are made by means of the numeral pendants without reference to the Code book, as per following examples:—

LATITUDE AND LONGITUDE

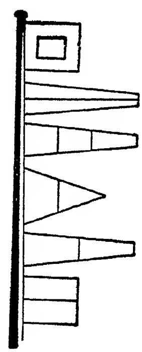
Letter *P* refers to position and is the top letter of the numeral hoist when signalling latitude and longitude.

P
3
6
2
4
N



Means Lat. 36° 24′ N., a six-flag hoist.

P
7
0
2nd sub
5
E



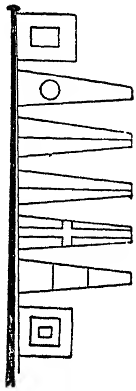
Means Long. 70° 05′ E., a six-flag hoist.

When the longitude is 100° or more the first figure need not be hoisted unless to prevent misunderstanding as to whether the degrees

are under or over the 100, thus Long. 176° 40′ W. may appear as hoists (i) or (ii).

(i.)

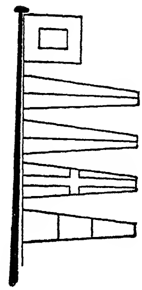
P 1 7 6 4 0 *W*



A seven-flag hoist

(ii.)

P 7 6 4 0



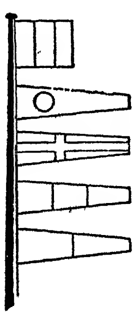
A five-flag hoist

Nor need the letters N or S (North or South) in latitude signals, or the letters E or W (East or West) in longitude signals be hoisted unless to avoid confusion should the latitude be near the equator, or the longitude close to the Greenwich or to the 180th meridians.

TIME SIGNALS.

The letter *T* refers to time and is the top letter of the numeral hoist when signalling hours and minutes. Time is expressed in four-figure notation, the first two figures of the group indicate the hours, the second two figures indicate the minutes, thus:

T 1 8 3 5



Means time 18h 35m

Greenwich mean time for chronometer comparison may be signalled in the same way, the first two numerals indicating the hour and the

second two numerals an approaching exact minute of time about to occur. The "exact" time will be that moment at which the signal is sharply hauled down.

An exact time may be signalled in the Morse code by first sending the time in advance and following the time signal with a LONG flash (dash) of about 5 seconds duration, the END of the flash (dash) being the exact time indicated by the four numerals.

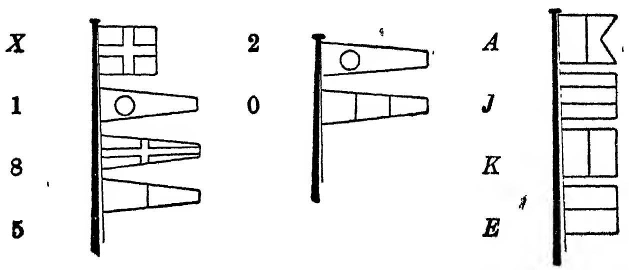
COURSES AND BEARINGS.

Letter *X* refers to courses and bearings. It is the top letter of the numeral hoist when signalling direction expressed in degrees from 000° to 359°, the direction to be read as TRUE courses or TRUE bearings unless expressly stated otherwise.

The position of a place may be signalled by means of its bearing and distance from a stated place, the procedure to be always in the order, BEARING—DISTANCE—PLACE.

Example—"185°, 20 miles from the Lizard" would appear in three hoists.

(i.) (ii.) (iii.)



185° 20 miles. The Lizard England

POINTS OF THE COMPASS.

Each of the 32 points of the compass is allocated a group of three letters in the Signal Code, thus *J U G* means N.N.E.; *N T L* means S.E., etc.

RELATIVE BEARINGS.

Bow, beam and quarter bearings for each point and for every 10° round the horizon are also given in the Code.

Examples—

A A A	means	1 point on the port bow.
A A H	„	on the port beam.
A B Q	„	3 points abaft the starboard beam.
A A W	„	80° to port.
A C G	„	120° to starboard.
R B F	„	right ahead.
R C A	„	right astern.

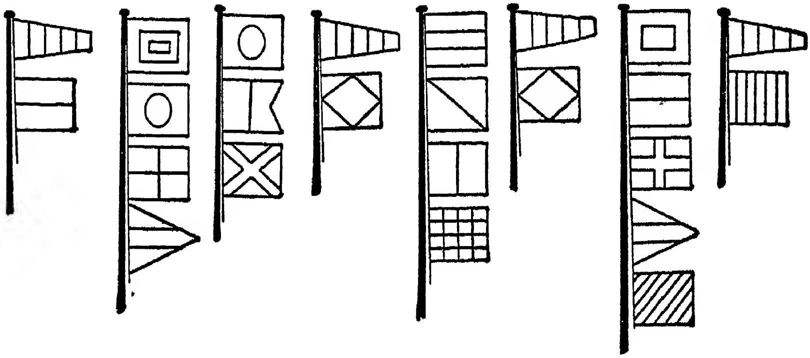
ALPHABETICAL SPELLING SIGNALS.

By this method each flag represents the actual letter of the alphabet corresponding to its name. Thus flag *A* stands for letter *a*, flag *B* for letter *b*, and so on, and this being understood, any name or word can be spelt by the flags themselves without referring to the Signal Book. When spelling by this method the three following signals must be used in order to indicate that the flags are to be given their alphabetical meaning for the purpose of spelling words:—

Signal	*Meaning*
Code Flag over *E* -	Alphabetical Signal No. 1 indicating that the flags hoisted after it, until alphabetical signal No. 3 is made, do not represent the signals in the Code, but are to be understood as having their alphabetical meanings, and express individual letters of the alphabet which are to form words.
„ „ *F*	Alphabetical signal No. 2 indicates the end of a word or dot between initials
„ „ *G* -	Alphabetical signal No. 3 indicates that the alphabetical signals are ended.

Example.—To spell William John Perry, the procedure would be as follows:

(i.) (ii.) (iii.) (iv.) (v.) (vi.) (vii.) (viii).



HOIST		MEANING
(i.)	Code E,	The letters which follow are alphabetical:
(ii.)	*WILL*	William
(iii.)	*IAM*	
(iv.)	Code F,	End of word
(v.)	*JOHN*	John
(vi.)	Code F,	End of word
(vii.)	*PERRY*	Perry
(viii.)	Code G,	End of spelling.

William may be signalled as one group by hoisting the flags "*W I L* 3rd substitute 2nd substitute *A M*".

Each hoist is kept flying until the receiving ship acknowledges it by hoisting her answering pendant.

EXCERPT FROM SIGNAL LETTERS FROM MERCANTILE NAVY LIST AND MARITIME DIRECTORY, 1932.

Official No	Name of Ship.	Internat' Code Signs and Wireless Call Sign	Port and Year of Registry.	Where and When Built.	Material.	Dimensions.			Registered Tonnage.		Horse Power of Engines.	Owner, or Part Owner, and Manager (if recorded). †Signifies *Managing Owner*. Italics signify *Manager*.
						Length.	Breadth.	Depth of Hold.	Net Tonnage	Gross Tonnage		
						ft. 10ths	ft. 10ths	ft. 10ths				
148935	Orotava	KWFD *GNBT*	Glasgow, 1927	Linthouse, 1927	S.	300 2	44 2	22 2	1515	2518	370	Elders & Fyffes, Lim, 31-32 Bow Street, London, W C.2. *William J. Geh, same address*
147202	Oroya	KNQB *GBFY*	Liverpool, 1923	Belfast, 1923	S.	525 3	62 8	40 6	7380	12257	1323	Pacific Steam Navigation Co., Goree, Water Street, Liverpool. *William Lewis, same address.*
122695	Orpheus	..	Grimsby, 1905	Selby, 1905	S.	120 0	21 6	11 5	91	228	69	Arctic Steam Fishing Co, Lim, Fish Docks, Grimsby *Edwin Bacon, sen, same address*
99236	*Orphir	NGQH	Leith, 1892	Govan, 1892	S.	175 4	26 4	13 8	207	459	200	†William Marshall, 94 Hope St, Glasgow
148852	Orsa	KSMQ	Glasgow, 1925	Schiedam, Holland, 1925	S	250 0	37 1	16 3	900	1478	120	Clydesdale Shipowners Co, Lim., 165 St Vincent Street, Glasgow *John C. Forgie, same address*
160865	Orsino	LFDM *GTRM*	Hull, 1929	Beverley, 1929	S.	140 9	25 5	14 1	143	380	99	Hull Northern Fishing Co, Lim, St. Andrew's Dock, Hull *Frank O Hellyer & Owen S. Hellyer, same address.*
128278	Orsova	HPFB *GLYF*	Glasgow, 1909	Clydebank, 1909	S.	536 2	63 3	34 3	6697	12041	866	Orient Steam Navigation Co, Lim, 3 and 5 Fenchurch Avenue, London *Sir Walter de M. Baynham, R B.E., same address.*

*Formerly the "Pole Star."

THE SIGNAL BOOK.

The following excerpts from the Signal Book are intended to convey an idea of the layout of the Book and to provide examples for exercise as given in the Catechism, page 660.

SPEED.

V Z You should increase your speed *to speed indicated*
W C You should proceed at your utmost speed
W D You should reduce your speed *to speed indicated*
W E Are you proceeding at full speed
W F What is your present speed

TOWING SIGNALS.

To be used only when towing and being towed.

These signals are to be made—

By Day.—A single flag, which may be exhibited by being held in the hand or by hoisting at the stay or fore shrouds, or at the gaff, according to circumstances.

By Night.—By flashing, care being taken not to confuse other ships.

Towing Signals.

	By the Ship Towing.		By the Ship Towed.
A	Is the towing hawser fast?	*A*	Towing hawser is fast
B	Is all ready for towing?	*B*	All is ready for towing
C	Yes (or affirmative)	*C*	Yes (or affirmative)
D	Shorten in the towing hawser	*D*	Shorten in the towing hawser
E	I am altering my course to starboard	*E*	Steer to starboard
F	Pay out the towing hawser	*F*	Pay out the towing hawser
G	Cast off the towing hawser	*G*	Cast off the towing hawser
H	I must cast off the towing hawser	*H*	I must cast off the towing hawse
I	I am altering my course to port	*I*	Steer to port
J	The towing hawser has parted	*J*	The towing hawser has parted
K	Shall I continue the present course?	*K*	Continue the present course
L	I am stopping my engines	*L*	Stop your engines at once
M	I am keeping away before the sea	*M*	Keep away before the sea
N	No (or negative)	*N*	No (or negative)
O	Man overboard	*O*	Man overboard
P	I must get shelter or anchor as soon as possible	*P*	Bring me to shelter or to an anchor as soon as possible
Q	Shall we anchor at once?	*Q*	I wish to anchor at once
R	I will go slower	*R*	Go slower
S	My engines are going astern	*S*	Go astern
T	I am increasing speed	*T*	Increase speed
U	You are standing into danger	*U*	You are standing into danger
V	Set sails	*V*	I will set sails
W	I am paying out the towing hawser	*W*	I am paying out the towing hawser
X	Get spare towing hawser ready	*X*	Spare towing hawser is ready
Y	I cannot carry out your order	*Y*	I cannot carry out your order
Z	I am commencing to tow	*Z*	Commence towing

Note.—The Towing Signals *C, E, I, N, O, S,* and *U* when made by the ship towing have the same meanings as those of the single-letter signals on page 625

TWO-LETTER SIGNALS.

Tow—Towing.

I am disabled. Will you tow me in or into place indicated *L J*

X S I am towing a float

X T I am towing a target

X U I cannot take you, or vessel indicated, in tow

I have parted towing hawser, can you assist me . . *D U*

X V I, or vessel indicated, require,s towing

X W I require a boat or tug to tow me to berth

X Y Can you take me in tow

X Z Shall I take you in tow

Weather.

Y T Bad weather is expected from direction indicated
Y U Gale is expected from the direction indicated
Y V Heavy gale coming: take necessary precautions
Cyclone, hurricane, typhoon is approaching. You should put to sea at once - - - - - - - - - - - - *G Y*
Thick fog is coming on - - - - - - - - - - *H U*
Y W Weather report is NOT available
You should prepare for a cyclone, hurricane, typhoon - *I K*
Y X You should wait until the weather moderates
Y Z Is bad weather expected
Z A What is the barometer doing
Z B What is the weather forecast for to-day
Z C What is the weather forecast for to-morrow

GENERAL CODE.

C E C BOAT, s
(Not to be used in the sense of ship)
C G L You should send your boat to pass towing hawser
C G M You should veer a boat astern
C G N Your boat, s should keep to leeward until picked up
Your boat, s should keep to windward until hoisted - *F Z*
C G O Are there any boats in sight
N L G SIGNAL,s
Signalling——*Am, Is, Are*
N L H Signalled——*Has, Have,ing*
N M J I wish to signal to vessel,s *number indicated if necessary* on bearing indicated from me
I wish to signal to you. Will you come within easy signal distance - - - - - - - - - - - *U Z*
N M K The signals are NOT intended for you
N M L Signal exercise finished
Signal is not understood though flags are distinguished - *V B*
You are flashing your signal too quickly - - - - *G H F*

Station

O B B STATIONED at (Located at)
O B C KEEP, s STATION, on
Keeping station, on——*Am, Is, Are*
O B D Kept station, on——*Has, Have,ing*

O B E TAKE,S STATION
Taking station——*Am, Is, Are*
O B F Taken, Took, station——*Has, Have,ing*
TOWING HAWSER,S - - - - - - - *R M X*
P F L I CANNOT send towing hawser
I have made chain cable fast to towing hawser - *C Q C*
I have parted towing hawser; can you assist me - - *D U*
P F M Towing hawser has parted
P F N Towing hawser is damaged
P F O Towing hawser is fast
P F P You should ease up dead slow, I want to secure towing hawser
P F Q You should have a towing hawser ready
You should shorten the towing hawser - - - *N H L*
You should veer the towing hawser - - - - *P T H*
P F R Are towing hawsers fast
P F S CAST,S off TOWING HAWSER,S
Casting off towing hawser's——*Am, Is, Are*
P F T You should cast off the towing hawser
P F U Cast off towing hawser,s——*Has, Have,ing*
P R B International Code of Signals

GEOGRAPHICAL SECTION.

A A C C	Adderley Hd. - - - - - -	*New Zealand*
A A C D	Adelaide - - - - - - - - -	*S. Australia*
A A C E	Adelaide, Port - - - - - - -	*S. Australia*
A A C F	Aden - - - - - - - - - -	*Arabia*
A A C G	Aden, G. of - - - - - - -	*Arabian Sea*

RELATIVE BEARINGS.

A A A	1 point on the port bow
A A B	2 points on the port bow
A A C	3 points on the port bow
A A D	4 points on the port bow
A A E	3 points before the port beam
A A K	3 points abaft the port beam
A A L	on the port quarter
A A M	3 points on the port quarter
A A N	2 points on the port quarter
A A O	1 point on the port quarter

A A P	10° to port
A A Q	20° to port
A A R	30° to port
A A S	40° to port
A A T	50° to port
A B V	10° to starboard
A B W	20° to starboard
A B X	30° to starboard
A B Y	40° to starboard
A B Z	50° to starboard

FLAGS TO BE FLOWN BY BRITISH MERCHANT SHIPS.

Section 74 of the Merchant Shipping Act, 1894, provides as follows:—

1. A ship belonging to a British subject shall hoist the proper national colours—

   (*a*) On a signal being made to her by one of His Majesty's ships (including any vessel under the command of an officer of His Majesty's Navy on full pay); and

   (*b*) On entering or leaving any foreign port; and

   (*c*) If of 50 tons gross tonnage or upwards, on entering or leaving any British port.

2. If default is made on board any such ship in complying with this section the master of the ship shall for each offence be liable to a fine not exceeding £100.

3. This section shall not apply to a fishing boat duly entered in the fishing boat register, and lettered and numbered as required by the fourth part of this Act.

SEMAPHORE.

Procedure.

1. The person intending to semaphore hoists semaphore flag (*J*) where most convenient and where best seen.

2. The other ship will then hoist the answering pendant at the dip to indicate that flag (*J*) has been observed, and when she is ready to read the message the answering pendant will be hoisted close up.

3. The sender keeps semaphore flag (*J*) flying while the message is being made and hauls it down on completion of the message.

4. All messages are semaphored in plain language and numbers occurring in a message are spelt out in words.

5. The special signs are, "Attention" and "Break" as per illustrations; Answering Sign (*C*) and a "succession of E's (*E E E E E E E E E*) to indicate that an error has been made. The Erase should be followed by the last word transmitted correctly and the message continued. *A R* means "end of message."

6. After sending each word the signalman drops his arms to the break position and waits until the receiver replies with the answering sign (*C*). If the receiver does not do so the sender repeats the word. When double letters occur in a word the sender drops his arms momentarily to the break position and carries on.

7. When vessels are a considerable distance apart and perhaps signalling with a mechanical semaphore, the receiving vessel acknowledges each word by means of the answering pendant.

8. When ships are close to one another the semaphore flag (*J*) and answering pendant need not be hoisted, but if not, the attention sign and answering sign (*C*) may be used instead.

9. When a number of ships are together and there is doubt as to which vessel is intended to answer the signal, the sender will hoist the particular vessel's signal letters, tack line *J*.

A man-of-war wishing to semaphore to a particular merchant vessel will do the same, viz., hoist signal letters, tack line *J* and in addition will hoist the Code pendant in a conspicuous position.

Use of Procedure Signals and Signs.

C (— · — ·).

The letter *C* signifies "You are correct."

When a word, or group, in the *text* of a message, is repeated back, the letter "*C*" is used by the transmitting ship to indicate to the receiving ship that the repetition has been made correctly.

De (— · · ·).

The word "De" used in the identity signifies: "From——." Thus: *De G X D E*, "From ship whose signal letters are *G X D E*."

G (— — ·).

The letter *G* signifies "Repeat back." It may be inserted at the beginning of the text of a plain language message, and is signalled separately. When so used it signifies: "Everything which follows in this message is to be repeated back, word by word, as soon as received."

R (· — ·)

The letter *R* signifies: "Message received."

T (—)

The letter *T* is used to indicate the receipt of each *word* in the text of a *plain language* message.

W (· — —)

The letter *W* used as a message in itself signifies: "I am unable to read your message owing to light not being properly trained or light burning badly." This is to be made by the receiving ship at any stage of the message, if required, and is to be answered by the transmitting ship showing a steady light until the receiving ship is satisfied with the light and ceases to make *W*.

Call for Unknown Ship and General Call.

The call for unknown ship and general call *AA AA*, etc. (· — · — · — · —, etc.), is used to attract attention when wishing to signal to a ship whose name is not known. It is the normal method of calling up at sea, and is to be continued until the ship addressed answers.

Answering Sign.

The answering sign $\overline{TTTTTTTT}$, etc. (— — — — — — — —, etc.), is used to answer the call. It is to be continued until the transmitting ship ceases to make the call.

Space Sign.

The space sign *I I* (·· ··) is used to separate the signs *A A*, *A B*, *W A* and *W B* from the identifying words or groups which follow them. It is also used to separate whole numbers from fractions.

Break Sign.

The break sign $\overline{B\,T}$ (—···—) is used to precede the text. It is to be repeated back, but its repetition by the receiving ship is not acknowledged with "*C*" by the transmitting ship.

Erase Sign.

The erase sign $\overline{EEEEEEE}$, etc. (········, etc.), is used to indicate that the last word or group was signalled incorrectly. It is to be answered with the erase sign. When answered, the transmitting ship will repeat the last word or group which was correctly signalled, and then proceed with the remainder of the message.

If the mistake was not discovered until after the message has been completely signalled, a new message must be made.

If it is desired to cancel the whole of a message while in process of transmission, the erase sign must be made, followed by the ending sign, viz., $\overline{EEEEEE}$ $\overline{AR}$.

Repeat Sign.

The repeat sign $\overline{UD}$ (··— —··) is used to obtain a repetition of the whole or part of a message.

To obtain a repetition of the whole message.

The repeat sign made singly signifies: "Repeat *the last* message." The repetition is signalled by making the message through in exactly the same form as it was originally transmitted. *Note.*—In Sound Signalling the repeat sign made singly signifies: "I missed the last word (or group), please go back a few words (or groups) and continue the message."

To obtain a repetition of a part of a message.

The repeat sign is used in conjunction with the signs *A A*, *A B*, *W A* or *W B*, and an identifying word or group, the last two being separated by the space sign thus:—

"$\overline{UD}$ $\overline{AA}$ $\overline{II}$ VESSEL," — signifies: "Repeat *all after the* word VESSEL."

"$\overline{UD}$ $\overline{AB}$ $\overline{II}$ JEM ," — signifies: "Repeat *all before the* group JEM."

"$\overline{UD}$ $\overline{WA}$ $\overline{II}$ KIC ," — signifies: "Repeat the *group after* KIC."

"$\overline{UD}$ $\overline{WB}$ $\overline{II}$ FLAGS ," — signifies: "Repeat the *word before* FLAGS."

If a message is not understood, or if a coded message, when decoded, is not intelligible, the repeat sign is NOT used. The receiving ship must then make the appropriate signal from the Signal Code.

Ending Sign.

The ending sign $\overline{AR}$ (· — · — ·) is used in all cases to end a message.

International Code Group Indicator "P R B."

In messages transmitted by means of the Morse Code, the International Code group indicator "*P R B*" is to be used as the first group of the coded text to indicate that the message which follows consists of Code groups from the International Code of Signals and not plain language.

SIGNALLING BY FLASHING

Component Parts of a Message

A message made by flashing is divided into the following components, although all of these components are not necessarily signalled in every message:—

1. Call. 2. Identity. 3. Break sign. 4. Text. 5. Ending.

How to Signal.

Component 1.—*The Call.*—The transmitting ship will commence signalling by making the call, which will be flashed continuously until answered.

The call consists of:—

(i.) The general call (*A A A A A A*) etc., or

(ii.) The signal letters of the ship to be called.

On observing the call, and when ready in all respects to read and write down, the receiving ship will answer by making the answering sign.

Component 2.—*The Identity.*—It will not always be necessary for two ships to establish their identity; should such necessity exist the two ships will carry out the following procedure: when the call has been answered the transmitting ship will make "de (from)," followed by her signal letters. This will be repeated back The receiving ship will then signal her own signal letters, which the transmitting ship will repeat back. If either ship fails to repeat back immediately, or repeats back incorrectly, the other will make her signal letters again until they are correctly repeated back.

Component 3.—*The Break Sign* ($\overline{BT}$) is next inserted. It is to be repeated back. but the transmitting ship does not in this case acknowledge the repetition by the receiving ship of the break sign ($\overline{BT}$) by making "*C*," for the reason that it is not a part of the *text*. If the receiving ship fails to repeat back the break sign ($\overline{BT}$) correctly, the transmitting ship will make "$\overline{BT}$" again until it is repeated back correctly.

The break sign is *not* inserted before the text of messages requesting repetitions.

Component 4.—*The text* consists of words of plain language or of groups of Code. Each word or group is signalled separately. The receiving ship will—

(*a*) Acknowledge the receipt of each plain language word with "*T*."

(*b*) Repeat back all Code groups, numbers signalled as figures (that is not spelt out), procedure signals and signs except "*C*" and punctuation signs. If the repetition is correct, the transmitting ship will made "*C*," if incorrect she will make the group again.

If the receiving ship does not acknowledge the receipt or repeat back, the transmitting ship should immediately signal again the last word or group.

Component 5.—*The ending* consists of the ending sign ($\overline{AR}$). The ending is answered by "*R*."

Omitting the Call and Identity.

When two ships are signalling for a considerable period and several messages are passed between them, the call and identity need be signalled in the *first* message only, in order to avoid delay.

Example 1.—A Simple Message.

Ship *Orotava* (signal letters *G N B T*) wishes to signal to ship *Oroya* signal letters *G B F Y*. the following message: "Owners have agreed to discharge cargo at Aden."

Component	Ship *Orotava* transmits	Ship *Oroya* receives and makes
Call	*A A A A A A* etc.	$\overline{TTTTTT}$ etc.
Identity	*De G N B T*	*De G N B T*
	G B F Y ←	*G B F Y*
Break Sign	$\overline{BT}$	$\overline{BT}$
Message	Owners	*T*
	have	*T*
	agreed	*T*
	to	*T*
	discharge	*T*
	cargo	*T*
	at	*T*
	Aden	*T*
Ending	$\overline{AR}$	*R*

NOTE.—The interchange of signal letters is always repeated in acknowledgment, but when identity has been established they are not repeated in further communication between the ships.

Example 2.—A Coded Message.

Messages may be morsed by transmitting the appropriate signal letters from the Visual Code book.

The letters *P R B* mean "The International Code of Signals." Group *K M C* means "Owners have agreed to discharge cargo at." Group *A A C F* means "Aden." An alternative method of Example 1 of making this message would be as follows:—The call and the break sign are made and answered as usual, but each Code group as above

when morsed is repeated by the receiving ship and acknowledged by the transmitting ship making *C*, meaning correct, before carrying on with the next group.

Component	Transmitting ship makes	Receiving ship makes
Call	$\overline{AA}$ $\overline{AA}$ $\overline{AA}$ etc.	$\overline{TTTTT}$ etc.
Break sign	$\overline{BT}$	$\overline{BT}$
Coded message	*P R B*	*P R B*
	C	
	K M C	*K M C*
	C	
	A A C F	*A A C F*
	C	
Ending	*A R*	*R*

Example 2.—**Coded Message as Morsed.**

The signalling of the message in Example 2 would appear in Morse in the following order, the signals in brackets being those of the receiving ship.

A	*A*	*A*	*A*	*A*	*A*	*T*'s		
·—	·—	·—	·—	·—	·—	(— — — — — —)		
B T	*B T*	*P*	*R*	*B*	*P*	*R*		
—···—	(—···—)	·——·	·—·	—···	(·——·	·—·		
B	*C*	*K*	*M*	*C*	*K*	*M*	*C*	
—···)	—·—·	—·—	——	—·—·	(—·—	——	—·—·)	
C	*A*	*A*	*C*	*F*	*A*	*A*	*C*	*F*
—·—·	·—	·—	—·—·	··—·	(·—	·—	—·—·	··—·)
C	*A R*	*R*						
—·—·	·—·—·	(·—·)						

Call (Answer) Break sign (Break sign) *P R B* "International Code of Signals" (*P R B*) Correct *K M C* "Owners have agreed to discharge cargo at" (*K M C*) Correct *A A C F* "Aden" (*A A C F* Correct Ending (Received)

Example 3.—**Ship " X" to " Ship " Y."**

Note.—The replies of Ship " Y " are the signals within the brackets.

```
.-  .-  .-  .-  .-  .-  (- - - - - - -)
-...-  (-...-)  .--  ....  .-  -  (-)
..  ...  (-)  -  ....  .  (-)  .--  .
.-  -  ....  .  .-.  (-)  ..-.  ---  .-.
.  -.-.  .-  ...  -  (-)  ..-.  ---  .-.
(-)  -  ---  --  ---  .-.  .-.
---  .--  (-)  .-.-.  (.-.)
```

Call (Answer) Break sign (Break sign) What (*T*) is (*T*) the (*T*) weather (*T*) forecast (*T*) for (*T*) to-morrow (*T*) Ending (Received.)

Ship " Y" to Ship " X." An example of repeat " all after."

Note.—The replies of Ship " X " are the signals within the brackets.

```
.-  .-  .-  .-  .-  .-  (- - - - - - -)  -...-
(-...-)  -.-.  -.--  -.-.  .-..  ---
-.  .  (-)  .-  .--.  .--.  .-.  ---  .-
-.-.  ....  ..  -.  --.  (-)  -.--  ---
..-  (-)  ...  ....  ---  ..-  .-..  -..  (-)
.--.  ..-  -  (-)  -  ---  (-)  ...  .
.-  (-)  ---  .-.  (-)  ...  -  .-.  .
-.  --.  -  ....  --.  (-)  --  ---
---  .-.  ..  -.  --.  ...  (..--..  .-.-
..  ..  ---  .-.)  ..--..  .-.-  ..  ..
---  .-.  (-.-.)  ...  -  .-.  .  -.  --.
-  ....  .  -.  (-)  --  ---  ---  .-.
..  -.  --.  ...  (-)  .-.-.  (.-.)
```

Call (Answer) Break sign (Break sign) Cyclone (*T*) approaching (*T*) you (*T*) should (*T*) put (*T*) to (*T*) sea (*T*) or (*T*) strengthen (*T*) moorings (Repeat all after, the word or) Repeat all after the word or (*C*) strengthen (*T*) moorings (*T*) Ending (Received).

Example 4.—**Aircraft to Ship**

Note.—The replies from the Ship are the bracketed signals.

.- .-   .- .-   .- .-   (- - - - - - -)   -...-
(-...-)   .--   ....   .-   -   (-)   ..   ...   (-)   --
-.--   (-)   .--.   ---   ...   ..   -   ..   ---
-.   (-)   .-.-.   (.-.)

Call (Answer) Break sign (Break sign) What (*T*) is (*T*) my (*T*) position (*T*) Ending (Received).

Ship to Aircraft.

Example of Numerals and Erase.

Note.—The Aircraft signals are those given in brackets.

.- .-   .- .-   .- .-   (- - - - - - -)   -...-
(-...-)   .--.   ....---   ...--   --...
(.--.   ....---   ...--   --...)   -.-.
.--.   ---..   .----   ....-   -....   ....
(..........)   .--.   .----   ---..   ....-
-....   (.--.   .----   ---..   ....-   -....)
-.-.   .-.-.   (.-.)

Call (Answer) Break sign (Break Sign) Position 52° 37′ (position 52° 37′) Correct Position 81° 46′ Erase (Erase) Position 18° 46′ (position 18° 46′) Correct Ending (Received)

EXAMPLES FOR EXERCISE.

Interpret the following Morse Messages.

1.

.- .-   .- .-   .- .-   (- - - - - - -)   -..   .
--.   .--.   .-.   -...   (-..   .   --.   .--.
.-.   -...)   (--   .-..   -.--   -)   --   .-..
-.--   -   -...-   (-...-)   --   -.--   (-)
.--.   ---   ...   ..   -   ..   ---   -.   (-)   ..
...   (-)   .--.   ..---   .----   .----
.....   (.--.   ..---   .----   .----
.....)   -.-.   .--.   ...--   -----
..---   ..---   (.--.   ...--   -----
..---   ..---)   -.-.   .-.-.   (.-.)

2.

.- .-   .- .-   .- .-   (-------)   -..   .
--.   -..   ...-   .-.   (-..   .   --.   -..   ...-
.-.)   (--.   --   --.-   -.)   --.   --
--.-   -.   -...-   (-...-)   -..   ..   -..
(-)   -.--   ---   ..-   (-)   ...   ..   --.
....   -   (-)   -..   .   .-.   .   .-..   ..   -.-.   -
(-)   .-.-.   (.-.)

3.

.- .-   .- .-   .- .-   (-------)   -...-
(-...-)   -.--   .   ...   (-)   -..   ..   ...   --
.-   ...   -   .   -..   (-)   .-   -.   -..   (-)
-..   .   -.-.   -.-   ...   (-)   .-   .--   .-   ...
....   (-)   ..-.   ..   ..-.   -   -.--   (-)   --
..   .-..   .   ...   (-)   ...   ---   ..-   -   ....
(-)   ..-.   .-.   ---   --   (-)   -.-.   .-
.--.   .   (-)   -.-.   .-..   .   .-   .-.   (-)
.-.-.   (.-.)

4.

.- .-   .- .-   .- .-   (-------)   -..   .
--.   -...   ..-.   -.--   (-..   .   --.   -...
..-.   -.--   (--.   -   .-.   --)   --.   -
.-.   --   -...-   (-...-)   .--.   .-.   -...
(.--.   .-.   -...)   -.-.   ---   -...   .
(---   -...   .)   -.-.   .-   .-   .-..   (.-   .-
.-..)   -.-.   .--   -.-.   (.--   -.-.)
-.   -.   .-.-.   (.-.)

5.

.- .-   .- .-   .- .-   (-------)   -...-
(-...-)   .-.   .   -.   -..   .   --..   ...-   ---
..-   ...   (-)   .--.   ..---   ...--   .----
----.   (.--.   ..---   ...--   .----
----.)   .--.   --...   --..   ...-   .....
(.--.   --...   --..   ....-   .....)   -....
...--   -----   (-)   .--.   --   (-)
.-.-.   (.-.)

6.

.— .—   .— .—   .— .—   (———————)   —...—
(—...—)   .... .— ...— .   (—)   —.—— ———
..—   (—)   — .... .   (—)   .—.. .— — . ... —
(—)   —. ——— — .. —.—. .   (—)   — ———
(—)   —— .— .—. .. —. . .—. ...   (—)
——— —.   (—)   —... ——— .— .—. —..
(—)   .—.—.   (.—.)

7.

.— .—   .— .—   .— .—   (———————)   —...—
(—...—)   —— —.——   (—)   .—.. .— — .
... —   (—)   —.—. ——— .——. —.——   (—)
.. ...   (—)   .——— ..— .—.. —.——   (—)
—. .. —. . — . . —.   (—)   — ....—.
— —.—— — .—— ———   (—)   .—.—.   (.—.)

8. Block Test.

——.	.—..	.——.	...	.
.—	....	——	—.——	—
——..	...—	..	—.	.—.
..—.	.—	.——	.———	———
—.—	——.	—...	—..—	—.—
.——.	.—..	....	—.—.	—.——
—	——.—	——	..	—..
...—	..—	.—.	—.	.———
—.——	—..—	.——	...	———
.—	——..	—.—.	.	..—.
—..	—...	——.	—..—	.——.

EXAMPLES FOR EXERCISE.

Interpretation.

1. Call (Answer) from *G P R B* (from *G P R B*) (*M L Y T*) *M L Y T* Break sign (Break sign) My (*T*) position (*T*) is (*T*) *P* 2115 (*P* 21° 15′) Correct *P* 3022 (*P* 30° 22′) Correct Ending (Received)

NOTE.—The message is from the ship holding signal letters *G P R B* to the ship whose signal letters are *M L Y T*.

2. Call (Answer) from *G D V R* (from *G D V R*) (*G M Q N*) *G M Q N* Break sign (Break sign) Did (*T*) you (*T*) sight (*T*) derelict (*T*) Ending (Received)

3. Call (Answer) Break sign (Break sign) Yes (*T*) dismasted (*T*) and (*T*) decks (*T*) awash (*T*) fifty (*T*) miles (*T*) south (*T*) from (*T*) Cape (*T*) Clear (*T*) Ending (Received)

4. Call (Answer) from *G B F Y* (from *G B F Y*) (*G T R M*) *G T R M* Break sign (Break sign) *P R B* (*P R B*) Correct *O B E* (*O B E*) Correct *A A L* (*A A L*) Correct *W C* (*W C*) Correct Ending (Received)

NOTE.—Refer to pages 548-551 and decode the above International Code groups as follows:

P R B	International Code of Signals
O B E	Take station
A A L	On port quarter
W C	You should proceed at your utmost speed

5. Call (Answer) Break sign (Break sign) Rendezvous (*T*) *P* 23 19 (*P* 23° 19′)
P 78 45 (*P* 78° 45′) 6 30 (*T*) *P M* (*T*) Ending (Received)

6. Call (Answer) Break sign (Break sign) Have (*T*) you (*T*) the (*T*) latest (*T*) Notice (*T*) to (*T*) Mariners (*T*) on (*T*) board (*T*) Ending (Received).

7. Call (Answer) Break sign (Break sign) My (*T*) latest (*T*) copy (*T*) is (*T*) July (*T*) nineteen (*T*) thirty-two (*T*) Ending (Received)

8. Block Test.

G L P S E	*K G B X K*	*Y X W S O*
U H M Y T	*P L H C Y*	*A Z C E F*
Z V I N R	*T Q M I D*	*D B G X P*
F A W J O	*V U R N J*	

SIGNALLING BY SOUND.

Caution.—The misuse of sound signalling being of a nature to create serious confusion in the highways at sea, the captains of ships should use these signals with the utmost discretion. Owing to the nature of the apparatus used (whistle, siren, foghorn, etc.) sound signalling is necessarily slow, and it is for this reason that it is necessary for ships to reduce the length of their signals as much as possible.

(*a*) Sound signalling in fog should be reduced to a minimum. Signals other than single-letter signals should be used only in extreme emergency and never in frequented navigational waters.

(*b*) For the reasons just stated the procedure indicated in the following example should be observed.

Example.—You are instructed to signal "What is the depth of water" by means of the steam whistle, no other system of transmission being convenient. Describe the procedure.

I would make a succession of double separate *A A*'s, until the receiving ship or station answered with *T*'s.

I would then morse the message, "What is the depth of water," then give ($\overline{AR}$) to indicate signal ended.

The receiving ship or station would then answer with (*R*) meaning received.

Assuming the reply to be 19 feet then

She would make *A A*'s ·— ·—   ·— ·—   ·— ·—

I would answer with *T*'s — — — — — —

She would make —· ·· —· · — · · —· ··—· · · —

then ($\overline{AR}$) ·—·—·

I would answer with (*R*) ·—· to indicate that I have received the message, viz., 19 feet.

NOTE.—The transmitting ship sends her message right through without waiting for acknowledgment by the receiving ship, but if the receiver misses a word or group he makes the repeat sign ($\overline{UD}$), on hearing which the transmitting ship will cease signalling and then go back a few words or groups and continue the message.

QUARANTINE SIGNALS

The following signals are to be shown on arrival by vessels requiring or required to show their state of health:—

In the Daytime.

Q flag—*signifying* - - - "My ship is 'Healthy,' and I request free pratique."

Q flag over first substitute (*Q Q*)—
signifying - - - - "My ship is 'Suspect,' *i.e.*, I have had cases of infectious diseases more than five days ago, or there has been unusual mortality among the rats on board my ship."

Q flag over *L* flag (*Q L*)—*signifying* "My ship is 'Infected,' *i e*, I have had cases of infectious diseases less than five days ago."

By Night.

Red light over a white light—
signifying - - - - - "I have not received free pratique."

(Only to be exhibited within the precincts of a port. The lights should not be more than 6 ft. apart.)

DISTRESS SIGNALS

(International Convention for Safety of Life at Sea, Convention for the Regulation of Aerial Navigation.)

When a vessel or aircraft is in distress and requires assistance, the following are the signals to be used or displayed either together or separately:—

In the Daytime.

(1) A gun or other explosive signal, fired at intervals of about a minute (for vessels only).

(2) The International Code Signal *N C*, signifying: "I am in distress and require immediate assistance."

(3) A continuous sounding with any fog-signal apparatus; in the case of aircraft, sound apparatus.

(4) The signal $\overline{SOS}$ made by Radiotelegraphy, or by any other distance signalling method.

(5) The distance signal, consisting of a square flag having either above or below it a ball or anything resembling a ball.

For aircraft only:—

(6) The signal consisting of a succession of white lights projected into the sky at short intervals.

(7) The International distress call "MAYDAY" (corresponding to the French pronunciation of the expression "m'aider") by means of Radiotelegraphy.

At Night.

(1) A gun or other explosive signal, fired at intervals of about a minute (for vessels only).

(2) Flames on the vessel (as from a burning tar barrel, oil barrel, etc.) (for vessels only).

(3) Rockets or shells, throwing stars of any colour or description, fired one at a time, at short intervals (for vessels only).

(4) A continuous sounding with any fog-signal apparatus; in the case of aircraft, sound apparatus.

(5) The signal $\overline{SOS}$ made by Radiotelegraphy, or by any other distance signalling method.

For aircraft only:—

(6) The signal consisting of a succession of white lights projected into the sky at short intervals.

(7) The International distress call "MAYDAY" (corresponding to the French pronunciation of the expression "m'aider") by means of Radiotelegraphy.

NOTE.—The instructions for the use of $\overline{SOS}$ and MAYDAY are contained in the Radiograph Regulations.

PILOT SIGNALS.

The following signals, when used or displayed together or separately, shall be deemed to be signals for a pilot:—

In the Daytime.

(1) The International Code Signal *G* signifying "I require a pilot."

(2) The International Code Signal *P T* signifying "I require a pilot."

(3) The Pilot Jack hoisted at the fore.

At Night.

(1) The pyrotechnic light, commonly known as a blue light, every fifteen minutes.

(2) A bright white light, flashed or shown at short or frequent intervals just above the bulwarks for about a minute at a time.

(3) The International Code Signal *P T* by flashing.

GALE WARNING SIGNALS

The Meteorological Office sends to certain Signal Stations a warning telegram on any occasion when a gale is expected to occur in the vicinity of the station. The fact that one of these notices has been received at any station is made known by hoisting a black canvas cone, 3 feet high and 3 feet wide at the base, which appears as a triangle when hoisted.

The SOUTH Cone (point downwards) is hoisted for gales commencing from a Southerly point; such gales often veer, sometimes to as far as North-west.

For gales commencing from East to West the SOUTH cone will be hoisted if the gale is expected to change to a southerly direction.

The NORTH Cone (point upwards) is hoisted for gales commencing from a Northerly point; for gales commencing from East or West the NORTH cone will be hoisted if the gale is expected to change to a northerly direction.

RADIO SIGNALS. VOLUME II.

The radio signals are arranged in five-letter groups representing various words, phrases and sentences which might be required to transact ship's business by wireless telegraphy. In common with all telegraphic codes it is necessary to be familiar with the contents and arrangement of the book in order to obtain from it the most accurate and economic results. The Code groups and the text are arranged alphabetically side by side, and a Table is provided so that the receiver may be able to trace and to rectify an error in a mutilated group as the Code groups are constructed on an arithmetical system that will ensure that they will differ from one another by at least two letters and that no two groups can occur containing the same five letters with a pair of adjacent letters inverted.

When International Code Signal groups of letters are to be transmitted by radio the message is preceded by "*I N T C O*" to indicate that the following is coded from the International Code of Signals. Bearings, courses numbers, latitude, longitude, time, etc., are expressed in five-letter Code groups.

When a message is to be sent a series of Code groups are selected to make up the desired message, the following being an example, taken from the Medical Section, of one ship asking from another the assistance of a doctor.

M O C A J	I have a sailor
K U E B P	Age 18
M O V M I	has compound fracture of
N A N N U	thigh
M O T B A	bleeding severely from wound
M O T O M	but has been arrested temporarily by tourniquet
M O T U V	bleeding cannot be stopped
N I M A C	Will your doctor come on board

CATECHISM.

1. How many hoists should be shown at a time?

Usually one hoist, but if more than one group of hoists are shown they should be kept flying until answered by the receiving ship.

2. Name the order in which several hoists should be read when displayed simultaneously.

(i) Masthead, (ii) triatic stay, (iii) starboard yardarm, (iv) port yardarm.

3. Suppose more than one group is shown on the same halyard, how are they separated and read?

They are separated. by a "tack" line about 6 feet long, and the groups are read in their order from the top group downwards.

4. A vessel is flying several groups of signals on different halyards at the same yardarm; in what order should they be read?

From the outboard yardarm hoist inwards.

5. Several hoists are shown from different halyards on the triatic stay; in what order should they be read?

From forward aft.

6. Define what is meant by superior and inferior signals.

Signals take their superiority from the order and position in which they are hoisted, the follow up groups being called inferior signals. The first signal hoisted is superior in point of time to the second one hoisted, and so on.

Similarly, they take superiority from the position in which they are hoisted, viz.: (i) masthead, (ii) triatic stay, (iii) starboard yardarm, (iv) port yardarm.

7. Describe the procedure of signalling to another ship.

I would hoist my signal letters, and when the other vessel replied by hoisting her answering pendant close up, or showing her signal letters, I would hoist each group in turn keeping each hoist flying until it was answered by the other vessel.

After completing the signal I would hoist my answering pendant close up. The receiving ship would do the same.

8. A vessel is flying your signal letters, what would you do?

She wants to communicate with me. I would hoist my answering pendant close up When she hauled the letters down I would lower my answering pendant to the dip and look out for her next hoist.

9. How can one tell if the Code pendant is at the dip?

Unless it is lowered well down it is sometimes difficult to see whether it is close up or not, especially if flown from the triatic stay, so it is better to hoist the answering pendant at the masthead or yardarm.

10 You cannot distinguish the signal made by another ship, or cannot decode them intelligibly; what would you do?

Keep my answering pendant at the dip and hoist:

U W—I cannot distinguish your flags. *Or,*

V B—Signal is not understood though flags are distinguishable.

11. How can you tell when a man-of-war is communicating with a merchant ship?

She flies the Code pendant in a conspicuous position during the whole time the signal is being made.

12. Decode the following signals from the specimen code given on pages 636 to 639:—

"Ship A hoists"

(i) *L J.* (ii) *A A C G.* (iii) Code flag.

(i) I am disabled; will you tow me into

(ii) Aden

(iii) Signal completed.

"Ship B hoists"

(i) *C.* (ii) *P F Q.* (iii) *O B E.* (iv) *A A C.* (v) *C G L.* (iv) Code flag.

(i) Yes

(ii) You should have a towing hawser ready

(iii) Am taking station

(iv) Three points on the port bow

(v) You should send your boat to pass towing haserw

(vi) Signal completed

13. Decode the following signal and explain the procedure and interpretation:—

(i) *G N B T.* (ii) *C G N.* (iii) *G L Y F*

(i) The first signal-letter hoist indicates that the signal is addressed to ship *Orotavo.*

(ii) Means "Your boat should keep to leeward until picked up."

(iii) The second signal-letter hoist indicates that the message is from ship *Orsova* instructing *Orotavo* what to do.

14. How is a geographical signal distinguished?

It is a four-flag hoist with letter *A* on top.

15. Are there any other special four-flag signals?

Yes; ship signal-letters are always four-flag hoists, the top flag and, in some cases the top two flags, of which indicate the nationality of the vessel. Thus letter *G* or *M* on top indicates a British vessel.

16. What is a substitute and what is it for?

A substitute is a triangular flag. There are three substitutes, 1st, 2nd and 3rd. They are used when a letter is repeated in a group, thus, *A A B B* would appear when hoisted as A 1st substitute, B 3rd substitute.

17. How is a numeral signal made?

By means of the numeral pendants, simply by bending them together in the order to make up the number, introducing substitutes when double figures appear in the groups.

18. How are position signals in latitude and longitude distinguished?

The top flag is *P*, followed by the numeral pendants giving the latitude and longitude.

19. How are time signals recognised?

The top flag is *T*, followed by numeral pendants giving the time in hours and minutes as per the four-figure notation.

20. If you are signalling the exact time by flags, or Morse, how is the exact instant transmitted to the other vessel?

An even minute is chosen and the hoist intimating the hours and this minute is hoisted a few minutes in advance. The signalman, as the time approaches, is on the alert to haul down the flags sharply whenever a timekeeper stationed at clock or chronometer calls out to him to do so. The moment of lowering the hoist sharply is the exact minute. The same system is adopted when morsing an even minute of

time. The time is signalled first, then a long flash is shown, the end of the flash being the exact time that has previously been signalled.

21 How are course and bearing signals distinguished?

By letter *X* being the top flag of the numeral hoist indicating the direction. Courses and bearings are given in degrees, true from 0° to 359°.

Bearings are signalled in the order

Bearing from Distance from Place

22 In the absence of the Code book, how may communication be established with International Code flags?

By spelling out each word, the preliminary hoist being Code over *E*, meaning "I am going to spell the words." Code over *F* is hoisted after each word, and Code over *G* is hoisted when the spelt message is finished.

23. What is a "weft"?

A weft is a flag with its fly tied to the halyards. It is now obsolete.

A weft was introduced to cover the period of transition from the old to the present system of signalling, a period during which both Codes were in use. The Code pendant as a weft, for example, meant "I wish to signal with the new International Code." This is no longer necessary.

24. When and by whom must National colours be shown?

By all British vessels when entering or leaving foreign ports, and on a signal being made from a Government ship. Vessels under 50 tons gross are exempted when entering or leaving British ports, so also are registered fishing vessels.

The master is liable to a fine of £100 for contravention of this regulation of the Merchant Shipping Act.

25. How is the signal "Man Overboard" made?

By hoisting flag *O*, and Morse *O* made on the whistle or by flashing.

26. What is the flag hoist for (*a*) in distress, (*b*) want a pilot?

(*a*) Letters *N C* or *W*, (*b*) letters *P T* or *G*.

27. Describe flag letter *C*.

A square flag having five equal horizontal stripes in the order downwards—blue, white, red, white, blue.

28. What is the Morse call sign and its answer?

A succession of double separate *A*'s, answered by a succession of *T*'s

29. What does *B T* (— · · · —) mean?

Just a break between the call up and the text of the message to be transmitted. It also serves to indicate that the receiver is ready to read. It is answered by the receiving ship repeating it back.

30. What does *G* (— — ·) signify?

It indicates that the sender wishes the receiver of the message to repeat back everything word for word as received instead of replying to each word by the general acknowledgment *T*.

31. What does *W* (· — —) signify?

It is made by the receiving ship at any stage of the message to inform the transmitting ship that her signal light is not properly trained or burning badly. The transmitting ship should show his signalling light steady whilst adjusting it until the receiving ship ceases to make *W*'s.

32. What is the space sign?

The space sign is *I I* (· · · ·) and is used to separate the repeat signs *A A* *A B* *W A* and *W B* from the words or groups asked to be repeated.

33. How may a mistake in sending be rectified?

By the sending ship making Erase (· · · · · · · ·) a succession of *E*'s, which is repeated by the receiving ship. The sender then repeats the last word or group which was correctly signalled and carries on with the rest of the message.

34. What does $\overline{UD}$ (· · — — · ·) mean?

It means repeat the message, or such part of it as may be indicated by *A A* (all after), *A B* (all before), *W A* (word after), *W B* (word before).

35. Describe flag letters *D*, *E*, *F*, *G*.

D is yellow, blue, yellow horizontal stripes, the blue being treble the depth of the yellow stripes.

E is blue over red horizontal half and half.

F is white with a red diamond.

G is six equal vertical stripes yellow and blue.

36. Describe the three substitutes.

The substitutes are triangular flags.

1st substitute is yellow with blue border.

2nd substitute is blue with white fly.

3rd substitute is white with a horizontal black stripe across the middle of it.

37. What are the functions of the Code flag?

(*a*) When hoisted preliminary to signalling it means that the 1931 International Code is to be used.

(*b*) When hoisted at the dip by a receiving ship it means signal seen, and when hoisted close up it means signal understood.

(*c*) It is used as an answering pendant to acknowledge each hoist as received.

(*d*) It indicates the decimal point in a numeral signal.

(*e*) It is associated with letters *E*, *F* and *G*, when spelling out words.

EXAMINATION PAPERS.

SECOND MATES.

Cargo Work and Elementary Ship Construction.

B.T. Specimen Paper. (3 *hours*)

1. If you sounded a double bottom tank and found 16 feet of water, what action should be taken?
2. What is a displacement scale? State its uses.
3. How is the draught of a vessel affected when passing from salt water to fresh water? Give reason The loaded draught of a vessel is 22 feet 6 ins. and the fresh water allowance $5\frac{1}{2}$ inches. The vessel is loading in dock, density of water 1016. Calculate draughts forward and aft, to which you would load, vessel to be 6 inches by the stern.
4. What is meant by (*a*) centre of gravity; (*b*) centre of buoyancy?
5. What are deep tanks and why are they fitted?
6. Give a brief description of (*a*) deck stringer; (*b*) panting beam; (*c*) beam knee.
7. What is a bilge keel? Give a rough sketch.
8. What precautions must be taken when loading general cargo for several ports?
9. State fully how a cargo of rice is stowed in a ship.

Paper 1.

1. What arrangements of derricks would you suggest for loading cargo and lifting 5 cwt. per sling?
2. How would you prepare a hold for loading a cargo of coal Describe the system of ventilation you would adopt.
3. Describe the gear you would use to take in bunker coal from a lighter in bags when filling the side bunkers.
4. Sketch and describe an arrangement of portable hatchway beams

5. Name the several components of (*a*) the transverse framing; (*b*) the longitudinal framing.
6. What are "strum" boxes and what precautions must be taken with them?
7. Two hundred iron tanks 3 ft. × 3 ft. × 2 ft. 6 ins. are stowed when empty in No. 3 hold, the ship's mean draught being then 18 ft. 6 ins. The tanks were then filled with beans in bulk at 48 cubic feet per ton. What will the mean draught be when the tanks are filled, the ship's T.P.I. being 35?
8. Find the total load on a double purchase and the pull on the hauling part of the fall when rove to advantage and lifting 20 cwt. State what allowance, if any, you have made for friction.

Paper 2.

1. How is the density of sea water ascertained? Distinguish between "density" and "specific gravity."
2. A cargo of grain in bags has just been discharged, describe fully how you would prepare the holds and be ready to load a general cargo.
3. A vessel at a mean draught of 14 feet has a deadweight of 1372 tons and at 15 feet mean draught her deadweight is 1588 tons. If the vessel has a mean draught of 14 ft. 6 ins. and loads an extra 50 tons, what would be her new mean draught, and what deadweight would she then have on board?
4. Sketch (*a*) a lap joint; (*b*) a butt strap joint.
5. What are the advantages and disadvantages of the "joggled" and the "out and in" systems of plating? Illustrate by sketches.
6. What are "crutches" and "panting beams"?
7. Assuming the righting levers (*GZ's*) of a ship at 10° heel to be ·5 ft.; at 20°, 1·1 ft.; at 30°, 1·6 ft.; at 40°, 1·95 ft.; at 50°, 1·7 ft.; at 60°, 1·1 ft.; at 65°, ·5 ft: construct a graph and from it find the righting arm at 25°, also the "range" of the ship's stability.
8. A caisson when filled with ballast weighs 10 tons and measures 200 cubic feet. What weight will be on the crane when the caisson is lowered into sea water?
9. A derrick is at an angle of 40° from a vertical mast. A weight of 10 tons is being lifted with a guntackle purchase, the hauling part leading from the upper block down the derrick to a winch at the heel of the derrick. Find the stress on the shackle at the derrick head, allowing one-tenth for friction at each sheave.

Paper 3.

1 How would you prepare a hold for a full cargo of jute, and how would you stow the bales?

2 Describe the preparations you would make regarding winches and cargo gear preparatory to discharging cargo.

3 Is ventilation provided for the bilges when a ship is fully loaded? Give reasons.

4 A ship's hold is 50 feet long, 28 feet broad and 20 5 feet deep In it is stowed a tier of barrels which go 250 to the tier. Each barrel stows at 12 cubic feet. What is the height remaining over the top of the barrels?

5. What is the function of a pillar? Show by a sketch how the head and heel of a pillar are connected to its adjacent parts.

6. What arrangements are made to allow water to flow from one transverse section to another?

7. Cargo has just been discharged from a deep tank, describe exactly what should be done before the order to fill it with water can be given.

8. A steamer's draught in light load condition is 10 ft. 6 ins. aft, 7 ft. 8 ins. forward. The following ballast tanks are then filled with sea water—No. 1, 186 tons; No. 2, 498 tons; No. 3, 219 tons; No. 4 221 tons; also her permanent bunker space of 19,980 cubic feet with coal at 45 cubic feet per ton. Assuming the T.P.I. to be 30, find the ship's new mean draught if she trims 2 feet by the stern.

Paper 4.

1. Describe in detail how you would prepare a hold for a cargo of grain in bulk.

2. How and where would you stow glass and grindstones as part of a general cargo?

3. What precautions against fire are taken when loading cotton?

4. A hold has a cubic capacity of 38,640 feet. At the bottom of the hold 643 packages (2 ft. × 1 ft. × 1 ft.) and weighing 200 lbs. are placed; 5 per cent. of the cubic capacity of the cargo is allowed for broken stowage. On top of this a parcel of 325 tons of wheat is placed stowing at 55 cubic feet to the ton. What tonnage remains in the hold at 40 cubic feet to the ton?

5. Define what is meant by the terms "centre of gravity" and "centre of buoyancy" as applied to a ship.
6. A box-shaped vessel when light has a mean draught of 2 feet and its loaded draught is 10 feet forward and 11 feet aft. If the T.P.I is 10, how much cargo can be loaded in the vessel?
7. What faulty distribution of cargo would produce (*a*) hogging; (*b*) sagging; (*c*) collapsing stresses?
8. Sketch and describe how beams are connected to the frames.
9. Draw a figure of the load line marks of a steamship, naming the several lines, and state to which edge a vessel is loaded.

Paper 5.

1. Is it advisable to use a swinging derrick when unloading a bag cargo? Give reasons.
2. State fully how you would dunnage and load a cargo of cement in barrels.
3. What precautions, if any, should be taken with deck winches in cold weather? Steam is escaping badly from the cylinders of a winch, what is this due to and how is it remedied?
4. What principal purposes do transverse watertight bulkheads fulfil?
5. What is a stringer plate? Sketch and describe how it is fitted at an upper deck.
6. The sea-cock of a double bottom is left open, the waterline is 10 feet above the top of the tank, the area of which is 1500 square feet. What is the total upward pressure on the tank top?
7. Given the following data, construct a graph:—

Mean draught	2 ft.	3 ft.	5 ft.	7 ft.
T.P.I.	4·7 tons	10·7 tons	13·6 tons	15·5 tons.

   If the vessel loads 40 tons of cargo at a mean draught of 4 feet, what is the change of draught.
8. What is meant by "pounding" and how is it counteracted?
9. Draw the following to scale:—Length of derrick 50 feet; from heel of derrick to span on mast 40 feet; angle between derrick and mast 30°; weight suspended from the end of derrick, 3 tons.

   From your figure find the approximate thrust on the heel of the derrick and the strain on the span.

Paper 6.

1. How is a cargo of rice ventilated?
2. Describe the permanent and portable dunnage usually fitted in ships.
3. Describe the usual arrangement of derricks and winches in an ordinary cargo ship.
4. Where should the following goods be stowed, and why:—Acids, explosives, oil in barrels, tallow?
5. Sketch an ordinary floor, describe it and name the parts to which it is attached.
6. What are "breasthooks"? Where are they placed, and why?
7. A hold of capacity 42,000 cubic feet has in it 150 tons of iron, stowed at 12 cubic feet per ton. How many bales of esparto grass can be stowed in the hold at 100 cubic feet to the ton and allowing 6 bales to the ton?
8. Define "centre of gravity" and state how it would be found in (*a*) a square plate; (*b*) a circular plate, omitting the thickness of the plate.
9. Explain why a piece of steel sinks when thrown into the water, and why a steel ship does not sink.

Paper 7.

1. Sketch a barrel and name its parts, including hoops.
2. How would you separate (*a*) parcels of timber; (*b*) parcels of rod iron?
3. How would you stow boxes of green fruit? Describe the arrangements made for ventilation.
4. How is a cargo of frozen meat ventilated? What precautions are taken when loading?
5. A ship's hold capacity is 34,440 cubic ft. 745 tons of coal are stowed in it at 42 cub. ft. per ton. 225 tons of rails are then put in to fill the hold. Find the stowage capacity of the rails.
6. Describe a watertight bulkhead and how it is connected to the adjacent parts.
7. What was the length of your last ship? How many bulkheads had she and how many of these were watertight?
8. A homogeneous log of rectangular shape measures $12' \times 2' \times 1'$. It floats in F.W. at a depth of 9 inches, what is its weight?

9. Construct a displacement curve for the following:—

Displacement tons	334	1020	1950	2930	3830	4840
Draught	2′ 6″	5′ 0″	7′ 6″	10′ 0″	12′ 6″	15′ 0″

Find draughts corresponding to 2340 and 4500 tons displacement.

Using above curve if the vessel started loading at 7′ 6″ draught and while loading she pumped out 510 tons ballast, find the cargo loaded if she completes loading at 15 feet draught.

Paper 8.

1. How would you tally a general cargo and what would you note in the tally book?
2. How do you stow a riding tier of barrels? How high do you stow barrels, hogsheads, puncheons, butts? State the capacity of each in gallons.
3. Describe the construction of a grain feeder used when loading grain in bulk. What percentage of the cargo should it contain?
4. How and where are explosives stowed? What precautions are taken when loading?
5. A hold having a capacity of 36,218 cub. ft. has stowed in it 212 tons of steel. The remainder of the space contains 626 tons of coal stowing at 45 cub. ft. Find the stowage of the steel in cub. ft. per ton.
6. Sketch and describe a single plate rudder.
7. What is the angle of maximum efficiency of the rudder and what prevents it going over too far?
8. A homogeneous log 8′ long and 18″ diameter floats half submerged in F.W., find weight of the log.
9. Construct a T.P.I. curve from the following data:—

Draughts	2 ft.	5 ft.	8 ft.	11 ft.	14 ft.
T.P.I.	8	13·5	16·2	17·7	18·5

Find T.P.I for draughts 7, 12 and 13 feet.

At a draught of 10 feet the vessel takes on board 25 tons F.W., find her new draught.

Paper 9.

1. How is cargo prevented from touching the ship's side while loading, and what additional precautions are taken when loading rice or a similar cargo?

2 What is "broken stowage" and where is it most likely to occur?

3. What would you do when discharging if you found damaged cargo?

4. What are shifting boards? When are they necessary and how are they erected?

5. The capacity of a hold is 48,696 cub. ft. In it are stowed 312 tons of slab marble at 18 cub. ft. per ton. How many cases of macaroni can be stowed above the marble if 35 cases occupy a ton space of 40 cub. ft.?

6 Sketch and describe a stern frame.

7. How is a propeller secured to the shafting?

8. A vessel has four W.T. bulkheads in the double bottom. How are the pipes led to the forward tank and how are they led through the bulkhead?

9. Construct a curve of displacement having given:—

Displacement tons	270	830	1370	2020	2750	3630
Draught in feet	2′	4′	6′	8′	10′	12′

(*a*) If the vessel's draught when light is 6′ 4″, what is her deadweight, her load draught being 12 ft.?

(*b*) If she has 510 tons of ballast on board what would her mean draught be?

Paper 10.

1. Describe the duties of a second mate when loading the following cargoes:—(*a*) A heterogeneous cargo. (*b*) Rice in bags from lighters. (*c*) A bag cargo of wheat for three ports.

2. Freight is charged at 24s. to the ton, measuring 40 cub. ft. per ton. A package 10′ 6″×4′ 6″×7″ weighs 7 tons 4 cwts. Find the freight (*a*) by weight; (*b*) by measurement.

3. What are intercostals? How are the compartments in a C.D.B. made accessible for inspection and cleaning?

4. What is a stem bar? How is it connected to (*a*) a bar keel; (*b*) to a flat plate keel?

5. A ship has a deep tank extending the breadth and depth of the vessel and has double bottom tanks of the same capacity. Will there be any difference in the effect of the C. of G. if these tanks are filled separately, and if so, for what reason?

6. A ship's starboard double bottom tank was filled up, how would this affect her centre of gravity?
7. A block of marble weighing 1 ton falls into the dock while discharging; would the strain on the cargo gear when lifting it to the surface of the water be greater or less than when lifting it out of the hold? Give reasons.
8. If a vessel displaces 100 tons in salt water what weight will she displace in F.W.?
9. Displacement tons 376 736 1352 2050 3140 4450
   Draught in feet 2′ 4′ 7′ 10′ 14′ 18′

Displacement tons	376	736	1352	2050	3140	4450
Draught in feet	2′	4′	7′	10′	14′	18′

At draught 8′ 8″ she loaded 750 tons and discharged 100 tons, find new draught. When she had discharged 2973 tons cargo and taken in 725 tons water her draught was 9 ft. Find her original draught.

Paper 11.

1. When discharging a bag cargo you find some bags empty and some torn, what action would you take?
2. How would you prepare a hold for, and stow, a cargo of frozen meat?
3. In what direction does heated air travel in a confined space? And of what benefit is this knowledge to a ship's officer?
4 Hold capacity 41,500 cub. ft., 14,500 bags of cement, weighing 112 lbs. per bag, are stowed at the bottom, the rest of the hold is filled with 403 measurement tons of 40 cub. ft. Find how many cub. ft. per ton the cement stows at.
5. How are dirt and mud prevented from entering the pipes used to pump out bilges and ballast tanks?
6. Describe a hatch coaming and how it is strengthened, and what parts of the structure are connected to it.
7. Describe and name the parts of a complete transverse member of an ordinary cargo steamer having cellular double bottom.
8. What is displacement? If the total volume of the immersed part of a vessel is 85,750 cub. ft., what is the equivalent in tons when the vessel floats in salt water?
9. Mean draughts and T.P.I.:

Mean draughts	3 ft.	6 ft.	9 ft.	12 ft.	14 ft.
T.P.I.	10·7	14·7	16·8	18·0	18·5

Find T.P.I. at 5, 7 and 13 ft. If the mean draught is 7 ft. and the vessel discharges 45 tons, find her new draught

Paper 12.

1. With two derricks at a hatch, rıg cargo gear for starboard side, to lift 30 cwt. at a time.
2. A hold has a capacity of 35,530 cub. ft. In it are stowed 10,400 bags of cement, each weighıng 70 lbs. and stowing at 35 cub. ft. to the ton. How many cases stowing at 22 per ton of 40 cub. ft. can now be stowed in the hold?
3. Describe how a centre through plate is connected in a C.D.B.
4. What is a margin plate? How is it connected to adjoining parts?
5. Explain carefully why some woods float and others sink?
6. A motor vessel burns all the fuel oil in her D.B. tanks, what effect will this have on her centre of gravity?
7. A vessel's volume of displacement is 393,503 cub. ft. Find her displacement in tons (*a*) in water density 1025; (*b*) in water of density 1015, at same draught.
8. From a scale of deadweight the following was taken:—Draught 18 ft. D.W. 4800 tons. Draught 18′ 6″, D.W. 4980 tons. How many tons of cargo would be required to immerse the vessel from 18′ 1″ to 18′ 4″ and what deadweight is there on board at the latter draught?
9. A homogeneous log of 18″ square section floats at even draught of 3″ with one face parallel to the surface of the water; find the height of the centre of gravity above the centre of buoyancy.

FIRST MATES.

Ship Maintenance, Routine, and Cargo Work.

B.T. Specimen Paper. (3 *hours*)

1. Your vessel has sustained damage leaving harbour. Where and how should this be recorded?
2. How often should the crew be exercised at boat drill? Draw up your routine for boat drill.
3. The bilges of your ship are choked and very dirty. State in detail how you would clean them.
4. What precautions must be taken when loading a full cargo of sawn timber?
5. How should a magazine for explosives be constructed?

6. The derricks of a vessel are tested to lift 5 tons each, no heavy derrick being available. There is a weight of 6 tons to be lifted out of the hold. What gear would you rig to land this weight on deck?
7. One of the steering chains has carried away. What action would you take?

Paper 1.

1. Describe types of slings and gear used for slinging different kinds of cargo.
2. Ship in ballast trim, you are to load general cargo in all holds. When and what tanks would you pump out, and give reasons?
3. Describe how you would prepare a ship for a cargo of grain in bulk when loading at a port in U.S A.
4. Describe how a wood deck is fitted on transverse beams. How would you prevent decay in wooden decks?
5. What entries are made in the mate's log book in port? Why is accuracy important with regard to log book statements?
6. A derrick 40 feet long has to lift a weight of 6 tons with a guntackle purchase. The span is made fast 50 feet above the heel and the purchase fall is led down the derrick. Find the stress on the span and the thrust on the derrick, assuming the weight plumbs a point 25 feet from the mast.
7. Describe the emergency steering gear of any ship you have served in.

Paper 2.

1. Prepare holds for a general cargo. Describe how you would stow it and distribute the weights.
2. What particulars would you give when indenting for the following stores:—Canvas, paint brushes, blocks, manila rope, shackles, reel for mooring wire, lugsail for life-boat, nuts and bolts?
3 The ship has just completed loading. State all that should be done with regard to hatches, cargo gear and cleaning up the decks preparatory to going to sea.
4. You are responsible for receiving cargo. What precautions should be taken to safeguard the ship's interests?

5. A ship of 3520 tons deadweight has on board 490 tons of stores, water and bunkers. Her hold capacities are No. 1, 55,100 c.f: No. 2, 55,970 c.f: No. 3, 44,100 c.f: No. 4, 35,900 c.f. It is required to stow phosphate at 35 c.f. per ton, and hay at 120 c.f. per ton to maximum capacity; find the quantity of each.

6. You are loading the following cargo:—What form of slinging would you adopt and what quantity per sling (i) iron tubes; (ii) bales; (iii) bags of salt; (iv) cement in casks; (v) oilman's small stores; (vi) reels of paper?

7. A span is formed by two pendants which make angles of 30° and 50° with two vertical masts. A load of 8 tons is hanging from the span; find by construction the load on each pendant.

Paper 3.

1. Describe in detail the rigging of a heavy derrick to lift a weight of 40 tons.

2. The bilges are rusted, how would you clean them and prevent subsequent rusting?

3. Where would you expect to find early indications of corrosion in a ship and state what you attribute the cause to?

4. Describe fully how a cargo of rice is stowed, dunnaged and ventilated.

5. What is meant by "ullage" in a tanker? What special precautions are taken when carrying petroleum spirit in bulk?

6. Describe the operation of dry docking a ship.

7. Loading esparto grass in bales (110 cub. ft. per ton) and ore in bags (15 cub. ft. per ton); ship's d.w. 3500 tons; stores, water and bunkers 480 tons; hold capacities, No. 1, 36,000 cub. ft.; No. 2, 37,500 cub. ft.; No. 3, 37,200 cub. ft.; No. 4, 35,300 cub. ft. Required the quantity of each to fill the ship to capacity. Draw a cargo plan and dispose the cargo in a single deck ship.

8. Two masts each 45 feet in height are 80 feet apart. Between the masts are two spans, one 35 feet, the other 60 feet long. At the point where they join a guntackle purchase is made fast, the hauling part leading down to a winch at the nearest mast. Find the stress on each span when lifting a weight of 2 tons, allowing for friction.

Paper 4.

1. How are the following goods stowed:—Frozen mutton, chilled beef bananas?
2. Describe the cargo gear carried in your last ship.
3. Discuss the question of dunnaging cargoes and what you consider to be a reasonable amount for various cargoes. What precautions would you take against the pilfering of cargo?
4. What precautions should be observed at sea when carrying a cargo of coal?

   No. 2 hold is heating very considerably, what would you do to prevent the coal going on fire?
5. Describe a type of steam steering gear and how the rudder is operated by the helmsman.
6. Coal is loaded into the bridge space bunker from six barges whose holds are 50 ft. long. × 6 ft. deep × 18 ft. wide at top × 16 ft. wide at bottom. After steaming for 12 days there remains a wedge of coal against a bulkhead whose triangular end is 6 ft. high × 10 ft. wide and whose length is 50 ft., also two full coal shoots each 4 ft. 6 ins. × 4 ft. 6 ins. × 22 ft. deep. Find the consumpt per day if the coal stowed at 45 cub. ft. per ton.
7. A derrick at an angle of 50° with a vertical mast is supported by a topping lift making an angle of 40° with the mast. Find the thrust on the derrick and the tension on the lift when a weight of 8 tons is suspended from the head of the derrick.

Paper 5.

1. How would you make cargo hatch openings perfectly watertight and secure?
2. You are loading the following cargo, in No. 2 hold, an equal weight of each item, construct your cargo plan and describe the manner of stowing and protecting the goods (*a*) iron tubes; (*b*) bales; (*c*) bags of salt; (*d*) cement in casks; (*e*) oilman's stores; (*f*) reels of paper.

   What stevedoring precautions should be taken when handling any of those goods?
3. A vessel of 5000 tons d.w. has 500 tons of coal and stores on board. She is to load 1000 tons manganese in bags at 25 cub. ft. per ton. Her total hold capacity is 275,000 cub. ft. Find the quantity of

jute at 66 cub. ft., and copra at 80 cub. ft., she can stow in the remaining space.

4. Describe the fire appliances in your last ship.
5. Why are the mate's receipts for cargo received of commercial importance? What particulars should he verify before signing?
6. Describe the load line marks on a ship over 330 feet in length.
7. What guarantee have you that the anchors and cables are in good order?
8. You join a strange ship as chief officer, what investigations would you make regarding her deck equipment, condition of holds, tanks and the ship's condition generally?

Paper 6.

1. Lifting a weight of 15 tons with a luff-tackle rove to disadvantage, find the total load on the upper block and the pull on the hauling part which is led vertically down, allowing 10 per cent. of the weight for the friction of each sheave.
2. What life-boat equipment must a cargo ship be provided with?
3. Describe bulkhead sluice valves and the attention they require.
4. Draw up a station bill for fire drill for a cargo steamship of 5000 tons deadweight.
5. What should the chief officer of a ship attend to with regard to receiving and stowing cargo for several ports?
6. A vessel has steamed 1600 miles at 12 knots on 32 tons of coal per day, find her speed to do 1800 miles with only 150 tons remaining.
7. State what you know of the conditions attached to carrying timber deck cargoes.
8. You are about to load a cargo of rice (50 cub. ft. to the ton). Ship's deadweight 4200 tons. Bunkers 450 tons. Cargo 900 tons for London, 900 tons for Hamburg, 1000 tons optional (London or Hamburg) and the remainder for Havre. Hold capacities No. 1, 42,500 cub. ft.; No. 2, 52,000 cub. ft.; No. 3, 50,800 cub. ft.; No. 4, 42,200 cub. ft. Show on a cargo plan how you would distribute this cargo. Order of discharge: Havre, Hamburg, London.

   What precautions would you take with regard to stowage dunnage, separation and ventilation?

Paper 7.

1. What is mill scale? Is it injurious or does it help to preserve the plate? How is it treated?
2. In ballast, loading at a single coal tip, when would you pump out your ballast tanks and in what rotation? What special precautions would you take?
3. Enumerate the entries made in the mate's log at sea, in port, and when lying at anchor.
4. Discuss the methods of ventilating a general cargo.
5. Describe fully how you would stow bag grain and state the precautions you would take against damage from sweat.
6. Describe in detail the construction of feeders for a bulk grain cargo.
7. A square cargo tray 4 feet by 4 feet, slung with four legs each 6 feet long meeting in a ring at the top, supports a weight of 15 cwts. Find the stress on each leg of the slings.
8. Stow any four of the following in one hold of an ordinary 'tween deck steamer:—Bags of manure, bags of flour, drums of asphalt, cases of dried fruit, cases of canned goods, cases of tinplate, barrels of cotton seed oil, bags of grain.

Draw a rough cargo plan showing the method of stowage, dunnage, separation and ventilation.

Paper 8.

1. What ventilation would you provide for green fruit in boxes for a short passage?
2. How would you separate different parcels of (*a*) coke, (*b*) rod iron, and (*c*) sawn timber?
3. What is the rough log and who keeps it?
4. Describe a suitable routine for the inspection and upkeep of lifeboats and life-saving appliances.
5. What precautions should be taken when pumping and draining double bottom tanks with one centre suction at the after end?
6. What precautions would you take when renewing deck planks over a steel deck?
7. A vessel 3890 tons deadweight has on board coal, stores and fresh water amounting to 520 tons. The hold capacities are:—No. 1 52,200 cub. ft.; No. 2, 55,600 cub. ft.; No. 3, 44,500 cub. ft.; No. 4,

40,200 cub. ft. The vessel has to be loaded down to her marks with the maximum quantities of wheat stowing at 48 cubic feet per ton and oats stowing at 80 cubic feet per ton. Required the quantity of each.

8. A beam 8 feet long weighs 4 tons. Find the minimum length of each leg of the slings required to support the beam if the safe working load of the only available wire is $2\frac{1}{2}$ tons.

Paper 9.

1. What routine duties would you assign to the carpenter?
2. A ship's company consists of the master, 3 mates, 4 engineers, 1 W/T operator, 4 stewards, 10 sailors, and 11 firemen. Draw up a plan of boat stations and allot duties to each man.
3. A white painted steel deckhouse shows signs of corrosion. State fully how you would treat it.
4. How would you mix cement for application to a double bottom and how would you apply it?
5. Describe how you would stow a full cargo of iron ore (*a*) in a 'tween deck vessel; and (*b*) in a single deck vessel.
6. What is meant by "bleeding" bags? Would you advocate this procedure?
7. A derrick makes an angle of 50° with a vertical mast and 12 tons is being lifted with a double purchase. Find the stress on the shackle at the derrick head allowing 10 per cent. for friction, also the stress on the shackle at the lead block at the derrick heel if the winch is 10 feet from the heel of the mast.
8. Find the approximate amount of paint required to cover the ship's bottom up to 15 feet draught allowing 1 cwt. of paint per 3000 square feet. Length 280 ft., breadth 38 ft., coefficient of fineness ·80.

Paper 10.

1. What entries are made in the mate's log after a collision?
2. What are the merits and demerits of patent driers? How would you treat lifeboat air tanks with a view to preserving them?
3. Describe in detail how you would treat new hatch covers and tarpaulins.

4. How do you measure rope and find its safe working load? How do you measure blocks? What size of block would you use with 2½" wire and with 3" manilla rope?
5. What are the duties of a watchkeeping officer with regard to ventilation of cargo?
6. (*a*) What is the difference between grain space and bale space? (*b*) Distinguish between deadweight and measurement cargo.
7. Ship 3300 tons deadweight. Stores and fuel 440 tons. Loading cotton at 70 cubic feet per ton as follows:—Osaka 900 tons; Osaka-Kobe (optional) 1000 tons; completing for Kobe. The hold capacities are:— No. 1, 49,700 cub. ft.; No. 2, 51,350 cub. ft.; No. 3, 41,570 cub. ft.; No. 4, 36,000 cub. ft. Describe the stowage, dunnage, separation and ventilation.
8. A three-fold purchase is used to lift out a 2-ton weight. A luff tackle is attached to the hauling part of the purchase. Find the minimum force required to lift out the weight and the stress on the supporting shackle allowing 10 per cent. for friction.

FIRST MATE.

Ship Construction and Stability.

B.T. Specimen Paper. (3 *hours*)

1. Sketch and name the various rolled sections used in ship construction.
2. What is the usual method adopted for distinguishing the strakes and plates of a ship?
3. What is a web frame? Give a rough sketch showing how it is built up.
4. Name the different members of the transverse framing in a ship with ordinary floors.
5. Define (*a*) reserve bouyancy, (*b*) displacement, (*c*) centre of gravity, (*d*) centre of buoyancy.
6. How does increase of freeboard affect stability?
7. In a vessel of 3000 tons displacement a weight of 100 tons is moved 20 feet, and a weight of 50 tons moved 10 feet upwards in a vertical direction. Calculate the effect on centre of gravity.
8. What is meant by a vessel being (*a*) stiff, (*b*) tender? What effect has the flooding of a double bottom tank on the stability of a ship?

Paper 1.

1. Show by means of a sketch how a frame and reversed frame are connected to a floor plate, indicating clearly the various connections.
2. What is a stringer? Sketch and describe a deck stringer
3. When and where are web frames introduced?
4. What stresses is a vessel in a seaway subjected to?
5. What is meant by a vessel being stable and unstable? Illustrate by sketches.
6. How is a curve of buoyancy constructed?
7. What is a bilge keel?

Paper 2.

1. Name the component parts of a transverse section of a ship having cellular double bottom.
2. Sketch a bar keel and a flat plate keel and explain how they are connected to the hull.
3. What system is adopted in a shipyard to identify a particular plate of shell plating?
4. Name the several parts which contribute longitudinal strength to the ship.
5. If you fill a double bottom tank at sea what difference will it make to the centre of buoyancy and the transverse metacentric height?
6. In a vessel of 3000 tons displacement it was found desirable to lower the existing centre of gravity which was 16 feet above the keel. A tank was filled with 250 tons of water, its centre of gravity being 3 feet above the keel. Required the height of the new centre of gravity.

Paper 3.

1. What are the advantages and disadvantages of joggled plating? Illustrate by a sketch.
2. Describe several forms of rivets used in ship construction.
3. How is a watertight bulkhead stiffened and how is it connected to the shell plating?
4. Describe the bilge and tank drainage system of a vessel you have served in.

5. Name and sketch the rolled sections used as ship's beams.
6. A vessel of 1600 tons displacement; centre of buoyancy 8 feet above the keel; centre of gravity 10 feet above the keel; transverse metacentre 11·5 feet above the keel Find the angle of heel if a weight of 8 tons is moved 20 feet across the deck.
7. When and by whom are ships surveyed for re-classification?

Paper 4.

1. Describe how a stem bar is connected to a flat plate keel.
2. Sketch a stern frame and name its several parts.
3. What are half beams? How, and to what are their inner ends connected.
4. Name the components which contribute longitudinal strength to the ship.
5. Draw a figure to illustrate a vessel in unstable equilibrium.
6. What effect on a ship's stability has slack water in a double bottom tank?
7. What is a stealer?

Paper 5.

1. What is meant by the "centre of pressure" of a rudder and where about is it situated?
2. How is the thrust of the propeller communicated to the hull?
3. Sketch and describe the construction of a cellular double bottom.
4. What are the advantages of having longitudinal bulkheads in cargo spaces?
5. Define "coefficient of fineness," and find ship's coefficient, having given, length 400 ft.; breadth 42 ft.; draft 21 ft. in S.W.; displacement tonnage 7640 tons.
6. Does corrosion take place more rapidly on the inside or outside of a vessel? Give reasons.
7. Explain how a curve of stability is constructed.

Paper 6.

1. Are solid floors always fitted at every frame in a cellular double bottom ship? If not, what is the alternative arrangement?
2. How are a web frame and a stringer united at their crossings?

3. Describe and illustrate by a sketch how a deck flat is made wate tight at the ship's side.
4 Illustrate and explain the various methods of connecting the but in shell plating.
5 What are "cant" frames and where and how are they fitted ?
6. A ship's load displacement is 3420 tons and its C.G is 12 feet abo the keel. Oil was consumed during the voyage as follows: 1C tons C.G. 1·5 feet above the keel, and 80 tons C.G. 6 feet above tl keel. Find the new centre of gravity. Show also how the initi transverse metacentric height will be affected if the transvers metacentre remains the same.
7. Who assigns the load lines to a ship?

Paper 7.

1. Distinguish between structural and local stresses as applied to stean ships. Where are local stresses usually found and what is done t guard against their effects?
2. Describe a complete transverse member in a ship with ordinary floor
3. Describe how a manhole door is fitted and made watertight.
4. Differentiate between web framing and ordinary framing.
5. What are tie plates and what useful purpose do they serve?
6. (*a*) Define displacement, deadweight and block coefficient. ((Define "buoyancy," "reserve buoyancy," "centre of buoyancy and "freeboard."
7. Ship 2000 tons displacement. A weight of 10 tons is moved 20 fee transversely across the deck. Find the shift of C.G. If tl vessel were upright before shifting the weight and she heeled { find the initial transverse metacentric height.

Paper 8.

1. Show by a sketch how a plated bulwark is fitted.
2. Sketch a main hold ventilator showing the connections to 'twee deck and lower hold.
3. Describe how decks are strengthened in the way of hatchways t compensate for the cutting of deck beams.
4. Explain the principal differences between a cellular double bottoı and a McIntyre tank

5. What is tipping moment? Define "inch trim moment" and longitudinal metacentric height.
6. A ship with a deck load of timber takes a very heavy list, what steps would you take to make her more seaworthy?
7. A box-shaped vessel floating upright at 7 feet draught is 180 feet long and 20 feet beam and 10 feet deep. She has no metacentric height. Find the G.M. when a weight of 40 tons is shifted from the deck to the bottom of the vessel.

Paper 9.

1. After crossing the North Atlantic, light ship in heavy weather, where would you particularly look for damage, and why?
2. Describe in detail the fitting and strengthening of shifting boards.
3. (*a*) What is meant by "breadth moulded," "depth moulded" and "length between perpendiculars?" (*b*) Define "deck sheer," "beam camber," and "tumble home."
4. (*a*) State the relative positions of the C.G., C.B., and the metacentre to obtain stable equilibrium. (*b*) If a weight is moved across the deck how does this affect the C.G , C.B. and the metacentre?
5. Define T.P.I., and state where it is generally found. Find the T.P.I. of a box-shaped vessel 210 feet long by 35 feet beam.
6. Describe the various transverse members in a cellular double bottom.
7. Ship 210 feet long is drawing 10 feet on even keel in salt water. A weight of 25 tons is moved 30 feet aft. Find the new draughts assuming the centre of flotation to be amidships and the I.T.M.= 250 foot-tons.

Paper 10

1. What is meant by opening up for survey and at what periodical intervals are these surveys held? Which survey is the most important?
2. How are the following tested for watertightness:—Double bottom tanks, collision bulkheads, hold bulkheads, and decks?
3. Sketch and describe a McIntyre tank.
4. Describe various methods of joining plates together and of connecting the raised strakes of plating to the frames.
5. (*a*) Define "righting arm" and "righting moment." (*b*) Given the K.G. of a light ship, how would you find the K.G. when loaded?

6. Ship 3000 tons displacement is in neutral equilibrium. A weight of 60 tons is lowered 20 feet into the hold. Find the metacentric height.
7. A box-shaped vessel is drawing 8 feet on even keel. A weight of 40 tons is moved 36 feet towards the stem. If the I.T.M. is 480 ft. tons, find the new draughts.

MASTERS.

Ship Construction and Stability.

B.T. Specimen Paper. (3 *hours*)

1. What are Lloyd's numerals and how are they obtained?
2. Sketch in outline a midship section of a ship built with ordinary floors, naming the various parts.
3. How is continuity of strength provided at the break of a raised quarterdeck?
4. What is a "joggled plate"? State its advantages and disadvantages.
5. What are the main features governing freeboard assignment?
6. What is the effect of concentrated loads in a ship? What would you consider a bad distribution of weight and buoyancy?
7. A box-shaped vessel 210 feet in length, 32 feet beam, and 16 feet depth floats on an even keel at draught of 8 feet. The G.M. is 2·8 feet. Calculate new G.M. after placing 64 tons on deck, vessel remaining on even keel.
8. A box-shaped vessel of same dimensions as above floats on an even keel at 8 feet draught. A weight of 50 tons is moved 40 feet forward in a horizontal direction. Calculate change of trim.

Paper 1.

1. Describe with sketches a plated bulwark.
2. Sketch the rolled sections used in ship construction and state where they are frequently introduced.
3. How are the butts of shell plating connected? A butt joint is "weeping," what would you do?
4. What is an "open survey"? Describe the chief requirements of a No. 3 survey.

5. A ship has a transverse metacentric height of 1·1 foot, and centre of gravity 12 feet above the keel. 200 tons of water ballast were taken in, the centre of gravity being 2 feet above the keel. Ship's displacement 3500 tons. Find the new metacentric height.
6. What is (*a*) moulded breadth; (*b*) moulded depth?

Paper 2.

1. Define Lloyd's numerals and give their use.
2. Sketch and describe a system of ventilation to a lower hold.
3. Sketch and describe a balanced freeing port.
4. Of what use are transverse bulkheads?
5. What precautions would you take when pumping up a ballast tank?
6. A vessel of 4500 tons displacement has a G.M. of 2·4 feet. A weight of 20 tons is moved 24 feet from amidships to one wing. Find the angle of heel.

Paper 3.

1. Where is the transom floor and how is it fitted?
2. Describe fully what is meant by a stiff ship.
3. Name the different Classification Societies and state how often ships are opened for survey.
4. Show by sketches how beams are joined to frames and frames to floors.
5. How are ballast tanks, bulkheads, and decks tested for water-tightness?
6. A box-shaped vessel 600 feet long is floating at a mean draught of 10 feet forward and aft. If I.T.M. is 240 foot-tons, find the new draught due to shifting 20 tons aft through 48 feet.

Paper 4.

1. Sketch and describe how a flat plate keel is fitted to a cellular double bottom.
2. Describe a margin plate and how fitted.
3. What is meant by the terms "tender" and "stiff"? Describe the condition to produce this in a vessel.
4. Define (*a*) deadweight; (*b*) tons per inch immersion.

5. A vessel of 4000 tons displacement has initial transverse G M. of 1·2 foot. 40 tons of cargo was lowered vertically 20 feet into the lower hold. Find the vessel's new G.M.

Paper 5.

1 Sketch a mast and describe the stepping of a mast in a modern steamer.

2. Define "buoyancy" and "centre of buoyancy."

3. What is "hogging"? Describe a simple method of determining whether a vessel is hogged or sagged.

4. Describe shifting boards and how they are fitted.

5. What is register tonnage? Who measures it and for what purpose?

6. A ship 1800 tons light displacement with C. of G. 10 feet above the keel loads 3400 tons, the C. of G. of which is 9 feet above the keel and 400 tons having its C. of G. 16 feet above the keel. Her final transverse metacentre is 12 feet above the keel. Find her metacentric height.

Paper 6.

1. Describe the stern tube of a single screw steamship and how water is prevented from entering the ship.

2. Describe how, and when, a curve of metacentres is constructed. Draw a rough metacentric curve to illustrate your answer.

3. What minimum number of watertight bulkheads are fitted in a steamship?

4. How is the stern of a ship strengthened to withstand pounding and vibration?

5. What are the special features of an "Isherwood" ship?

6. A vessel's draught was 17 ft. forward and 16 ft. 8 ins. aft. Her T.P.I. was 21 tons and her I.T.M. 275 foot-tons. Her No. 5 tank, holding 78 tons and 50 feet from amidship, was filled. Find her new draught.

Paper 7.

1. Show by means of a sketch a transverse bulkhead in a tonnage opening. What governs the spacing of tonnage openings?

2. What is a hawse pipe? How is it fitted?

3. Describe how wooden decks are fitted when there are no steel decks.
4. Describe an oxy-acetylene blow-lamp and its uses.
5. Describe and sketch a cellular double bottom with solid floors at alternate frames.
6. A vessel of 1700 tons displacement having her centre of gravity 17 feet above the keel takes the following cargo on board:—

3600 tons wheat,	C.G.	16 ft.	above keel.
1000 tons barley	C.G.	20	,,
100 tons oats	C.G.	10	,,

What is the height of her centre of gravity when loaded.

Paper 8.

1. What is "synchronism"? How and why should it be avoided?
2. What is the difference between a cellular double bottom and a McIntyre tank?
3. What is meant by length between perpendiculars, moulded breadth, moulded depth?
4. Sketch a stern frame and show how it is connected to the hull of the vessel.
5. (*a*) What are metacentric curves? (*b*) Define "metacentric stability."
6. At the commencement of a voyage a vessel has a displacement of 4500 tons and a K.G. of 11 feet. Initial metacentric height 1 foot. During the voyage she consumes 150 tons of bunkers from No. 3 hold with a K.G. of 14 feet and 150 tons of water are run into No. 4 tank with a K.G. of 2 feet. Find the metacentric height on arrival.

Paper 9.

1. How is a mast stepped (*a*) with a single deck; (*b*) with two decks?
2. How are the following tested for watertightness:—(*a*) ballast tanks; (*b*) collision bulkheads; (*c*) decks?
3. Sketch a midship section of a cargo steamer. State the type of vessel selected, and the system she is built on. Give length, breadth, depth, also spacing of frames.
4. What is statical stability? What information could you derive from a curve of stability?
5. Describe how a stern tube is connected in a single screw steamer, and illustrate by means of sketches.

6 A vessel's centre of gravity is 8 feet above the centre of buoyancy and 10 feet above the keel. The transverse metacentre is 11·5 feet above the keel and the ship's total displacement is 1600 tons. A weight of 8 tons is moved athwartships 20 feet. Find the angle of heel.

Paper 10.

1. What is the meaning of the following expressions heard in shipyards doing repairs:—(*a*) Chopping; (*b*) off and fair; (*c*) fair on?
2. How are rivets in a riveted joint tested? What is the pitch of rivets in (*a*) shell plating; (*b*) margin frame angles; (*c*) tank reverse angles?
3. What is meant by opening out for survey, and at what periodical intervals are the surveys extended?
4. Sketch a section through a hatchway and show the connections of hatchway beams and coamings.
5. Define transverse metacentre and initial transverse metacentric height. A vessel of 5000 tons displacement, transverse metacentre 18 ft. above the keel and centre of gravity 15 8 ft. above the keel. The vessel is heeled 7°. Find her righting moment.
6. A vessel is 3330 tons displacement, has a draught 17 ft. forward and 16 ft. 6 in. aft. Her T.P.I. is 21 tons and her I.T.M. 275 foot-tons. Her No. 5 tank, which holds 78 tons, is run up. Find her new draught if the centre of gravity of the ballast is 50 feet abaft the tipping centre assumed amidships

ANSWERS.

EXAMINATION PAPERS.

SECOND MATES.

Cargo Work and Elementary Ship Construction.

B.T. Specimen Paper.

3. Draught 22 ft. 5 ins forward; 22 ft. 11 ins aft.

Paper 1.

7. Draught 18 ft 8·7 ins.
8. Load 28 cwt Pull 5 6 cwt., allowing 10 per cent. of load for each sheave for friction

Paper 2.

3 Draught 14 ft. 8·8 ins. D.W. 1530 tons.
7. GZ at 25° = 1·4 ft. Range 69°.
8. Weight on crane 4 285 tons.
9. Stress 15 1 tons.

Paper 3.

4. Height 18 ft. 4·3 ins.
8. Draught 12 ft. 5 ins. forward; 14 ft. 5 ins. aft

Paper 4.

4. 181·55 tons.
6. 85 tons × 12″ = 1020 tons.

Paper 5.

6. Pressure 428·5 tons.
7. Change of draught 3·3 ins.
9. Thrust 3·8 tons. Stress 1·9 tons.

Paper 6.

7. 2412 bales.

Paper 7.

5. 14 cubic feet
8. 10 cwt.
9 2340 tons at 8 ft. 6 ins.; 4500 tons at 14 ft. 2 ins.; cargo 3400 tons

Paper 8.

5. 38 cub. ft. per ton.
8. 4·93 cwt.
9 15 3 tons at 7 ft.; 18 tons at 12 ft; 18 22 tons at 13 ft.; draught 10 ft 1 5 ins

Paper 9.

5. 37,695 cases.
9 (*a*) 2160 tons; (*b*) 7 ft. 10 ins.

Paper 10

2. £8 12s. 10d. by weight. £9 18s. 5d. by measurement.
8. 100 tons.
9. (*a*) 11 ft 4 ins.; (*b*) 17 ft. 00 ins.

Paper 11.

4. 35 cub ft. per ton.
8 2450 tons
9. 13 3 at 5 ft.; 15 4 tons at 7 ft.; 18·3 tons at 13 ft.; draught 6 ft. 9 ins.

Paper 12

2. 13,266 cases.
7. (*a*) 11,254; (*b*) 11,144.
8 90 tons. 4920 tons deadweight.
9. 7 5 ins.

FIRST MATES.

Ship Maintenance, Routine and Cargo Work.

Paper 1.

6. Thrust 8 4 tons. Stress 4 tons

Paper 2.

5. Hay 1000 tons. Phosphate 2030 tons
7. Loads 6·2 tons, 4·2 tons.

Paper 3.

7. Ore 1960 tons = 29,400 cubic ft.
   Grass 1060 tons = 116,600 cubic ft.
8. Tension 2·45 tons on short span, 2·9 tons on long span. Stress at span connection 2·9 tons.

Paper 4.

6 Consumpt 52 24 tons per day.
7. Thrust 6 1 tons. Tension 5 1 tons.

Paper 5.

3. Jute -	2143 tons	=	141,438 cubic ft.
Copra -	1357 tons	=	108,560 cubic ft.
Manganese	1000 tons	=	25,000 cubic ft.

Paper 6.

1. Load 21·5 tons+weight of tackle. Pull 6 5 tons.
6. Speed 10·39 knots.

8. Hold	No. 1	No. 2	No. 3	No. 4
Capacity	42,500 cu. ft.	52,000 cu. ft	50,800 cu. ft.	42,200 cu. ft.
Percentage capacity	22½ °/o	27½ °/o	27½ °/o	22½ °/o
Havre	214	256	256	214
London	202	248	248	202
Hamburg	203	248	248	203
Optional	225	275	275	225

NOTE—Figure out for each hold its percentage of the total capacity of the ship, then distribute the cargo for each port on this basis of percentage.

Paper 7.

7. 4·3 cwts. on each leg.

Paper 8.

7. 2409 tons wheat, 961 tons oats.
8. Length 6·7 feet.

Paper 9.

7. 15·5 tons at derrick head. 8·5 tons at the heel.
8. 5·2 cwts. paint.

Paper 10

7. Hold	No. 1	No. 2	No. 3	No. 4
Capacity	49,700 cu. ft.	51,350 cu. ft.	41,570 cu. ft.	36,580 cu. ft.
Percentage capacity	27¾ °/o	28¾ °/o	23½ °/o	20¼ °/o
Osaka	250 tons	259	209	182 tons
Optional	277	288	232	203 ,,
Kobe	166	276	223	104 ,,

8. Force 3·5 cwts. Stress 2·53 tons.

Ship Construction and Stability.

B.T. Specimen Paper.

7. C. of G. moves up 9 9 inches

Paper 2.

6. C. of G 15 feet above keel.

Paper 3.

6 Heel 3° 24′.

Paper 5.

5 Coefficient ·75.

Paper 6.

6. C. of G 12 47 ft. above keel. *GM* reduced ·47 ft.

Paper 7

7. Shift of C.B. 0·1 ft, G M 0 7 ft.

Paper 8.

7. G.M. $\frac{5}{8}$ ft

Paper 9.

5. T.P.I. 17·5 tons.
7. 9 ft. 10½ ins. ford.; 10 ft. 1½ ins. aft.

Paper 10.

6. G G.[1] 0 4 ft. G.M. 0·4 ft
7. 7 ft. 10½ ins ford.; 8 ft. 1½ ins. aft

MASTERS.

Ship Construction and Stability.

B.T. Specimen Paper.

7. This example is complicated owing to lack of information. It is worked in six steps as follows:—

(i) To find BM at 8 ft. draught.

Waterline rectangular 210′ × 32′.

Transverse moment of inertia = I.

$$I = \frac{LB^3}{12} = \frac{210 \times 32^3}{12} = 573440 \text{ ft.}^4$$

Volume of displacement $= V = 210' \times 32' \times 8' = 53760 \text{ ft.}^3$

$$BM = \frac{I}{V} = \frac{573440}{53760} = 10{\cdot}67 \text{ ft.}$$

(ii) To find height of C.G. before adding 64 tons.

C B at half draught - - - -		$KB = 4\ 00$ ft
		$BM = 10\ 67$
		$KM = 14{\cdot}67$
	Given	$GM = 2\ 80$
C.G. above keel - - - -		$KG = 11{\cdot}87$ ft.

(iii) To find rise of C.G due to adding 64 tons at 16 ft. above keel
$16 - 11\ 87 = 4\ 13$ ft.

Displacement in tons at 8 ft. draught $= \frac{V}{35} = \frac{53760}{35} = 1536$ tons

New displacement $= 1536 + 64 = 1600$ tons.

Rise in ship's C.G $= \frac{64 \times 4{\cdot}13}{1600} = 0{\cdot}17$ ft.

$\therefore\ KG_1 = 11{\cdot}87 + {\cdot}17 = 12\ 04$ ft.

(iv) To find new $BM = B_1M_1$.

$B_1M_1 = \frac{I}{V} = \frac{573440}{1600 \times 35} = 12{\cdot}04$ ft.

(v) New draught.

T.P.I. $= \frac{LB}{35 \times 12''} = \frac{210 \times 32}{420} = 16$ tons.

Increase of draught $= \frac{64}{16} = 4'' = {\cdot}33$ ft.

$\therefore$ New draught $8{\cdot}33$ ft.

(vi) New height of metacentre and new GM.

$KB_1 = 4\ 17$ ft. at half draught.
$B_1M_1 = 10{\cdot}24$

$KM_1 = 14{\cdot}41$
$KG_1 = 12{\cdot}04$

$G_1M_1 = 2{\cdot}37$ ft.

8. The solution of this question requires three steps as follows:—

(i) To find longitudinal BM.

Longitudinal moment of inertia $= I = \frac{BL^3}{12} = \frac{32 \times 210^3}{12}$
$= 24{,}696{,}000$

Longitudinal $BM = \frac{I}{V} = \frac{24{,}696{,}000}{53{,}760} = 459\frac{3}{8}$ ft.

(ii) Moment to change trim 1 inch.

I.T.M. $= \frac{W \times GM}{12L} = \frac{1536 \text{ tons} \times 459\frac{3}{8} \text{ ft.}}{12 \times 210 \text{ ft.}} = 280.$

Assuming $BM = GM$ to be a good approximation.

(iii) To find change of trim.

$$\text{Trimming moment} = 50 \text{ tons} \times 40 \text{ ft.}$$
$$= 2000 \text{ ft tons}$$
$$\text{Change of trim} = \frac{2000}{280} = 7\tfrac{1}{7} \text{ inches by the head.}$$

Paper 1.

5. New GM 1 6 feet.

Paper 2.

6. Heel 2° 33′.

Paper 3.

6. Draught 9 ft. 10 ins. forward; 10 ft. 2 ins aft.

Paper 4.

5. New GM 1 4 ft.

Paper 5.

6. GM 2 18 ft.

Paper 6.

5 Draught 16 ft 8 6 ins. forward, 17 ft. 6 8 ins. aft.

Paper 7.

6. K G.=16·8 ft.

Paper 8.

6. G M =1 4 ft.

Paper 9

6. $\theta=3° 49'$.

Paper 10.

5. Moment 1340 foot-tons.
6. Draught 16 ft. 8 6 ins ford., 17 ft 4 8 ins. aft.

INDEX.

INDEX.